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# LIGHTNING FIRES IN SOUTHWESTERN FORESTS

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# LIGHTNING FIRES IN SOUTHWESTERN FORESTS (1)

by

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(1) Research performed for Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station under cooperative agreement 16-568 CA with Rocky Mountain Forest and Range Experiment Station.

Final Report

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# LIGHTNING FIRES IN SOUTHWESTERN FORESTS

## I. INTRODUCTION

Lightning is the leading cause of fires in southwestern forests. On all protected private, state and federal lands in Arizona and New Mexico, nearly 80 percent of the forest, brush and range fires are ignited by lightning. The Southwestern region leads all other regions of the United States both in total number of lightning fires and in the area burned by these fires.

Lightning fires are an important factor in the management of wildland resources in all of the western United States and especially on the 139 million acres under organized fire management in Arizona and New Mexico. On these lands in the Southwest an annual average of nearly 2400 lightning fires occur. These fires are a natural element in wildland ecosystems and under precisely specified conditions some lightning fires may be used beneficially in natural resource management. Lightning fires also adversely impact society causing losses of needed natural resources, human life and property.

This report presents a summary of research aimed at gaining an in-depth understanding of the nature and magnitude of Southwestern lightning fires. The research focuses on lightning fire factors related to the development of policies and programs for overall management of forest and range resources. Information is presented for evaluation of both ecological and societal aspects of lightning fires. The main data base is some 28,000 individual fire reports from national forests and general fire summaries of more than 48,000 fires in Arizona and New Mexico The research also analyzes lightning fires in national forest wilderness and primative areas and wilderness study areas.

## I-1. Lightning and Man-Caused Fires

A first step in the development of this research involves an overview of both lightning and man-caused fires. While the objective is clearly to concentrate on lightning fires, it is necessary to understand the relative role of both lightning and man-caused fires in resource protection and management.

Forest fire statistics show the importance of both lightning and man-caused fires in Arizona and New Mexico (U.S. Forest Service, 1960-1975). As shown in Table I-1, a total of 37,934 lightning fires and 10,138 man-caused fires were reported on protected state, private and federal lands in the two states during the 16-year period 1960-1975. Lightning accounted for 78.26 percent of the fires in Arizona and 80.14 percent in New Mexico. The largest number of both causes of fires was in Arizona.

Analysis of fires on all protected lands in the various western regions shows that the Southwestern region accounts for 26.95 percent of the lightning fires but only 5.88 percent of the man-caused fires. The Southwestern region leads all other western regions both in total number of lightning fires and in percent of fires caused by lightning (78.91%). The Northern Rocky Mountain region (Idaho and Montana) ranks second to the Southwest in percent of fires caused by lightning (65.07%). The Pacific Northwest region (Oregon and Washington) ranks slightly higher than the Northern Rockies in total number of lighting fires (Table I-1).

As shown in Table I-2, Arizona leads all western states in number of lightning fires per million acres and ranks sixth in man-caused fires. New Mexico ranks fifth in lightning fire density and tenth in man-caused fires. Only Nevada has a lower density of man-caused fires than New Mexico.

Further insight into the general scope of lightning and man-caused fires is gained by examining the fire records of the six western regions of the U.S. Forest Service. Region Three (Southwest Region, USFS) leads all other western regions both in total number of lightning fires and in area burned by these fires. As shown in Table I-3, during the 16-year period 1960-1975 lightning fires in Region Three national forests accounted for 80 percent of the fires and 65 percent of the area burned in the region. Only Region One (Northern Rockies) recorded a higher percentage of area burned by lightning fires.

This overview emphasizes the dominant role played by lightning fires in the Southwest and especially in the Region Three national forests. However, this does not suggest an unimportant impact by man-caused fires. As shown in Table I-3 the average annual area burned by man-caused fires in Region Three is second only to Region Five (California).

Table I-1. Number and Percent of Lightning and Man-Caused Fires on all Protected Private State and Federal Lands in Twelve Western States, 1960-1975

| State and Region | Lightning Fires No. | % | Man-Caused Fires No. | % | Total No. |
|---|---|---|---|---|---|
| Arizona | 24,528 | 78.26 | 6,815 | 21.74 | 31,343 |
| New Mexico | 13,406 | 80.14 | 3,323 | 19.86 | 16,729 |
| Total Southwest | 37,934 | 78.91 | 10,138 | 21.09 | 48,072 |
| Colorado | 5,921 | 34.41 | 11,287 | 65.59 | 17,208 |
| Wyoming | 3,375 | 46.11 | 3,944 | 53.89 | 7,319 |
| Total Central Rockies | 9,296 | 37.90 | 15,231 | 62.10 | 24,527 |
| Idaho | 17,423 | 65.98 | 8,985 | 34.02 | 26,408 |
| Montana | 11,377 | 63.73 | 6,474 | 36.27 | 17,851 |
| Total Northern Rockies | 28,800 | 65.07 | 15,459 | 34.93 | 44,259 |
| Nevada | 3,041 | 46.63 | 3,481 | 53.37 | 6,522 |
| Utah | 4,677 | 45.25 | 5,660 | 54.75 | 10,337 |
| Total Intermountain | 7,718 | 45.78 | 9,141 | 54.22 | 16,859 |
| California | 25,903 | 25.69 | 74,942 | 74.31 | 100,845 |
| Oregon | 21,372 | 50.09 | 21,291 | 49.91 | 42,663 |
| Washington | 7,733 | 25.30 | 22,836 | 74.70 | 30,569 |
| Total Pacific Northwest | 29,105 | 39.74 | 44,127 | 60.26 | 73,232 |
| Alaska | 2,005 | 38.33 | 3,226 | 61.67 | 5,231 |
| Total West | 140,761 | 44.97 | 172,264 | 55.03 | 313,025 |

Table I-2. Fire Occurrence Density on Protected State, Private and Federal Lands in Western States, 1960-1975.

| State | Lightning Fires | | Man-Caused Fires | |
|---|---|---|---|---|
| | Average Annual No. of Fires Per Million Acres | Ranking | Average Annual No. of Fires Per Million Acres | Ranking |
| Arizona[1] | 45.72 | 1 | 12.70 | 6 |
| New Mexico | 20.65 | 5 | 5.13 | 10 |
| Colorado | 11.16 | 8 | 21.27 | 4 |
| Wyoming | 5.84 | 10 | 6.81 | 9 |
| Idaho | 24.89 | 4 | 12.85 | 5 |
| Montana | 17.37 | 7 | 9.89 | 7 |
| Nevada | 3.32 | 11 | 3.81 | 11 |
| Utah | 6.52 | 9 | 7.90 | 8 |
| California | 28.29 | 3 | 81.83 | 1 |
| Oregon | 29.57 | 2 | 29.46 | 3 |
| Washington | 18.73 | 6 | 55.35 | 2 |
| Total Western States | 138.756<br>8,672<br>18.93 | | 10,564<br>23.06 | |

[1] Arizona figures will change in the future because of recent addition of protection to large areas of arid lands where fire occurrence is low.

Table I-3. Summary of Occurrence and Area Burned for Lightning and Man-Caused Fires in Western Forest Service Regions, 1960-1975

| | Region | | | | | | |
|---|---|---|---|---|---|---|---|
| | R-1 | R-2 | R-3 | R-4 | R-5 | R-6 | TOTAL |
| **Lightning Fires** | | | | | | | |
| Total No. | 15,934 | 5,641 | 29,973 | 11,380 | 19,275 | 17,840 | 100,043 |
| Annual Ave. | 996 | 353 | 1,873 | 711 | 1,205 | 1,115 | 6,253 |
| % of Regional Total | 74 | 59 | 80 | 60 | 53 | 56 | |
| % of Western Total | 16 | 6 | 30 | 11 | 19 | 18 | |
| Acres Burned | 225,835 | 69,088 | 383,006 | 141,355 | 115,381 | 288,821 | 1,223,486 |
| Annual Ave. | 14,115 | 4,318 | 23,937 | 8,835 | 7,211 | 18,051 | 76,468 |
| % of Region Total | 71 | 49.8 | 65 | 54 | 9 | 65 | |
| % of Western Total | 18 | 6 | 31 | 12 | 9 | 24 | |
| **Man-Caused Fires** | | | | | | | |
| Total No. | 5,463 | 3,986 | 7,555 | 7,609 | 16,787 | 13,900 | 55,300 |
| Annual Ave. | 341 | 249 | 472 | 476 | 1,049 | 869 | 3,546 |
| % of Regional Total | 26 | 41 | 20 | 40 | 47 | 44 | |
| % of Western Total | 10 | 7 | 14 | 14 | 30 | 25 | |
| Acres Burned | 92,566 | 69,607 | 204,084 | 120,133 | 1,140,878 | 155,348 | 1,782,616 |
| Annual Ave. | 5,785 | 4,350 | 12,755 | 7,508 | 71,304 | 9,709 | 111,413 |
| % of Region Total | 29 | 50.2 | 35 | 46 | 91 | 35 | |
| % of Western Total | 5 | 4 | 11 | 7 | 64 | 9 | |
| **Total All Fires** | | | | | | | |
| No. Fires | 21,397 | 9,627 | 37,528 | 18,989 | 36,062 | 31,740 | 155,343 |
| Annual Ave. | 1,337 | 602 | 2,346 | 1,187 | 2,253 | 1,984 | 9,708 |
| % of Western Total | 14 | 6 | 24 | 12 | 23 | 21 | |
| Acres Burned | 318,401 | 138,695 | 587,090 | 261,488 | 1,256,259 | 444,169 | 3,006,102 |
| Annual Ave. | 19,900 | 8,668 | 36,693 | 16,343 | 78,516 | 27,761 | 187,881 |
| % of Western Total | 11 | 5 | 20 | 9 | 41 | 14 | |

## I-2. Background For The Research

This research of lightning fires in Southwestern Forests is motivated by several factors including:

(1) The significance of lightning fires to fire management and overall planning and management of multiple resource programs.

(2) The major advances in knowledge of lightning phenomena (especially the results of Project Skyfire research at the Northern Forest Fire Laboratory).

(3) The need for development of an in-depth understanding of lightning fires to aid in application of Skyfire and other research results to specific features of the Southwestern environment.

When the Forest Service organized Project Skyfire in 1953 in cooperation with several other agencies the research objectives were: (a) to gain basic information on the occurrence, behavior and control of lightning-caused forest fires and the characteristics of storms that produce these fires; and (b) to develop methods for suppression of lightning fires, including study of cloud modification as a possible means of preventing or reducing the severity of lightning fires (Barrows et al., 1957).

Early in the Skyfire program, Region Three of the Forest Service became one of the focal areas for the Research. In 1956, a Skyfire research team including members from the Weather Bureau, Munitalp Foundation, Meteorology Research, Inc., and the Forest Service established studies on the Coconino National Forest. Working from headquarters at the Fort Valley Experimental Forest, studies were initiated of lightning storm characteristics in the San Francisco Peaks area and at other locations on the Coconino and Sitgreaves National Forests. These sites were chosen because of the unique opportunities for study of convective cloud phenomena in a region known to have a high occurrence of lightning fires. Mt. Elden on the Coconino and other forest fire lookouts were used as key observation points.

The Arizona studies pioneered several important methods for lightning fire research. Cloud and lightning observation methods developed earlier in the Northern Rockies were tested in the Southwest (MacCready, Schaefer, Dieterich and Barrows, 1955). The first Skyfire mobile radar unit was employed in monitoring cloud development and movement. Both ground based and

airborne silver iodide generators were used to explore cloud seeding effects on lightning storm systems. Two aircraft were used to observe and record special features of clouds and fires (Barrows et al., 1957). Following the pioneering Skyfire experiments in the San Francisco Peaks area, many other meteorological research groups found the advantages of this site for cloud, lightning and weather modification studies.

Many years of Skyfire research both in Arizona and the Northern Rockies have produced results of great potential significance to fire and natural resources management. These include:

(1) Lightning characteristics. The special features of some lightning strikes that are most likely to ignite forest fires have been discovered and documented in the Northern Rocky Mountains (Fuquay, Taylor, Hawe and Schmid, 1972). These fire igniting strikes are characterized by a long continuing current phase and are now commonly known as LCC strikes. It may be postulated that very large numbers of LCC strikes occur in the Southwest and are directly related to the very high lightning fire occurrence in the region.

(2) Lightning sensing. Technology has been developed for measuring and recording lightning features and tracking lightning storms from both ground based stations and aircraft (Fuquay and Baughman, 1969; Fuquay, 1975). This technology has a high potential for beneficial use in fire management.

(3) Prevention of lightning fires. Intensive research has demonstrated that lightning fires may be prevented through proper application of weather modification technology (Baughman, Fuquay and Mielke, 1976; Fuquay, 1975; Fuquay and Baughman, 1969; Barrows, 1966). The results of these studies have undergone rigorous examination by the scientific community and by agencies responsible for management of natural resources (Interdepartmental Committee for Atmospheric Sciences, 1971).

(4) Fire danger rating. The National Fire Danger Rating System includes a subjective estimate for lightning risk (Deeming, Burgan, and Cohen, 1978). Currently the results of Skyfire lightning and other research are being applied in the development of a much more complete and definitive model for rating and predicting lightning fire potential.

In 1974 Dr. Donald M. Fuquay of the Northern Forest Fire Laboratory suggested that future research on lightning and applications of existing technology in fire management would benefit from an in-depth analysis of lightning fires in various forest regions. The initial approach would be to up-date

previous analyses of forest fires in the Northern Rocky Mountains (Barrows, 1951). As a result of these suggestions the Forest Fire Science Program at Colorado State University initiated research of lightning fires in Region One under terms of a Forest Service grant. The primary data base for these studies was the individual fire reports from Region One national forests for a 28-year period. CSU developed a series of special computer programs to facilitate the analyses. A final report on this research was prepared in 1976 (Barrows, Sandberg and Hart, 1976).

During the course of the research on lightning fires in the Northern Rockies, it was suggested that similar studies should be made for Southwestern Forests. It was recognized that the intense lightning fire zones in Forest Service Region Three should be prime targets for an in-depth analysis. The results of such studies could aid in further linkage to Skyfire and other fire research and could foster applications to fire and natural resource management in the Southwest. Many of the lightning fire analytical methods and computer programs developed for the Region One studies could also be adapted for use in Region Three. Accordingly in 1975, Colorado State University initiated research of lightning fires in the Southwest again under terms of a Forest Service grant arranged by the Northern Forest Fire Laboratory and the Intermountain and Rocky Mountain Forest and Range Experiment Stations.

Several other factors provide motivation for research of lightning fires in Forest Service Region Three. Fire management policies and programs are undergoing changes. Increasing recognition is being given to the natural role that lightning fires play in ecosystems. Fire management is seeking appropriate methods to facilitate this role. In many situations, there will be critical fire management decisions affecting both ecosystems and society. Special considerations are needed for wilderness fires and possible impacts of these fires on adjacent non-wilderness resources. Criteria are needed for unwanted and wanted fires (Barrows, 1974). Fire management costs are increasing at an accelerated rate. Fire impacts on needed resources are of continuing importance. All of these factors suggest the need for an enlarged understanding of lightning fires.

## I-3. Research Objectives and Methods

### Purpose

The main purpose of the research is to provide detailed knowledge of the lightning fire situation in Southwestern National Forests. The knowledge will provide input for fire management decisions such as fire intelligence needs, presuppression and suppression activities and prediction of resource impact in various forest areas; and to research activities in fire occurrence simulation fire management systems analysis, and identifying research directions. A valuable data base will be established for future research and resource management.

### Objectives

Specifically, the research will:

1. Describe the distribution of lightning fire occurrence in Region Three. The variation in the temporal and spatial density of fires will be related to years, short time periods, topography, forest types, and fuel types for each National Forest, zone, and the Region as a whole.

2. Describe statistically the influence of fuel, topography, and fire ignition on the severity of lightning fire problems. Define the critical fire problem in terms of the fire environment features associated with large outbreaks of fires, area burned, and fire management operations. Analyze the feature of lightning fire situations having various degrees of severity.

3. Describe the historical occurrence of ciritcal and non-critical lightning fire situations. Identify any non-random features in the location, time or frequency of problem situations.

4. Locate and define critical fire areas, if they exist, i.e., areas with a non-random, recurrent lightning fire load.

5. Describe the recent historical occurrence of fires within existing and proposed Wilderness Areas. Analyze the potential fire load in Wilderness Areas. Propose a model for utilizing historic wilderness fire data in analyzing probably long-term effect, of lightning fires in wilderness.

## Data Base

The primary data for this research comes from the individual reports of more than 28,000 lightning fires occurring in Region Three national forests during the 15-year period 1960-1974. Other data used in selected parts of the analyses stem from annual National Forests Fire Reports (U.S. Forest Service, Washington, D.C.), annual Wildfire Statistics (Division of Cooperative Fire Protection, U.S. Forest Service, Washington, D.C.), and various publications describing the forests, climate and environment of the region. Supplemental data were obtained from U.S. Forest Service reports and maps.

The individual fire report data were obtained on magnetic tape. An enormous amount of work was required to clean up the data and develop it in a proper format for computer aided analysis. Errors and omissions had to be corrected on several hundred fires. A special computer program was used to identify some of the errors. The data clean-up program included searches of fire reports on file at GSA Federal Record Centers and many contacts with the Forest Service Regional Office, Washington Office and National Forest Supervisors Offices. As a result of this work the individual fire data are in reasonably accurate form. In some cases changes in coding instructions or omissions that could not be filled in prevented continuity or fully complete data on certain phases of the studies. For example, the wilderness fire studies could be made for only seven years and it was necessary to totally eliminate fire danger rating analyses. However, for most of the studies, the data base provides a wealth of significant information.

Following clean up of the data, new magnetic tapes were prepared. On these tapes, all data for both the 1960 and 1970 decades were recorded in a common coding format developed at CSU. The fire data in this format will be provided to the Forest Service and will also become a part of the CSU fire science data bank system.

## Research Methods

This entire research effort involves the use of data gathered by others. Some additional observations stem from the experience of the authors. The basic methodology for the research required the development or adaptation of computer programs, data processing formats and analytical and statistical procedures.

We adopted a procedure of examining the fire data in two major dimensions:

(1) Temporal -- years, months, periods of days and individual days.

(2) Spatial -- region, states, zones, groups of national forests, individual areas (including wilderness, primitive, wilderness study and non-wilderness areas).

In parts of the fire analyses the Region Three National Forests were subdivided into four zones as follows:

Southwestern Zone
- Coronado National Forest
- Tonto " "

Northwestern Zone
- Coconino National Forest
- Kaibab " "
- Prescott " "

Central Zone
- Apache-Sitgreaves National Forest
- Gila " "

Eastern Zone
- Carson National Forest
- Cibola " "
- Lincoln " "
- Santa Fe " "

Several special computer programs were prepared for this research. All programs were written in CDC Extended Fortran.

| Program | Purpose |
|---|---|
| BUF2CSU | Converts a USFS buffered tape containing individual fire reports, to a formated tape compatible with CSU Fire Science programs, while standardizing all data codes to one base set. |
| CRITLD | Scans the data for days which a specified number of ignitions, previously determined to be a critical fire load, in either the region as a whole, all wilderness areas, or both and outputs the appropriate table. |
| TABLES3D | Provides a three way stratification of any two user-specified variables. |
| REGANAL<br>FORANAL<br>ZONANAL | Produce a tabular output of the fire load and fire size class distribution for each day, ten-day period, month, and year for each forest, zone, and the region as a whole. |

The data from these computer outputs are presented as follows:

(1) Summarized in tables, figures or narrative material in the text.

(2) Supplementary information summaries in the Appendix.

(3) A data bank furnished in a series of magnetic tapes for computer use.

The narrative descriptions and conclusions on lightning fires are those of the authors prepared following appropriate analytical and statistical procedures.

## II. THE LIGHTNING FIRE LOAD ON THE NATIONAL FORESTS

In fire management fire load has often been a term describing the volume, difficulty and overall magnitude of forest fire operations. The definition of fire load as applied to this research is "the total impact of fire occurrence and fire growth on the requirements of management organizations to meet natural resource protection and utilization objectives." The studies of fire load concentrate first on the basic features of fire occurrence, size class of fires and area burned. Later in this report, attention is given to other factors including fire environment, fire control and critical lightning fire situations.

Lightning fires in Forest Service Region Three have several distinctive features that characterize the dimensions of the fire load. These include:

(1) A long fire season.
(2) Great variations in fuel flammability during the fire season.
(3) Large numbers of lightning fires during most fire seasons.
(4) Occasional simultaneous occurrence of fire ignitions and weather conditions favoring development of large fires.
(5) Distinctive areas of maximum fire occurrence.
(6) Distinctive areas having a high potential for large lightning fires.

## II-1. Lightning Fire Occurrence

### Regional Fire Occurrence

High annual occurrence of lightning fires is a constant event in Region Three. During the 36-year period 1940-1975, a total of 59,518 lightning fires occurred in Region Three national forests. This is an annual average of 1653 fires. As shown in Table II-1, fewer than 1000 fires occurred during only two fire seasons -- 1941 and 1955. More than 2000 lightning fires have occurred during ten fire seasons. The peak occurrence during the 36-year period was 2841 lightning fires in 1961.

The reported number of lightning fires is increasing. As shown in Table II-1, the average annual lightning fire occurrence has increased in each decade since 1940-1949. The average annual occurrence of 1386 fires in the decade of the 1940's has increased to 2098 fires in the 1970-1975 period. The reasons for this substantial increase are not clear. A combination of factors may be involved including better surveilance of lightning storms, improved fire detection, increased fuel flammability and changing methods in fire cause identification. However, the data does clearly show that Region Three has a continuing lightning fire load of great magnitude.

Average annual lightning fire occurrence in Region Three is 86 fires per million acres. This figure for fire density was determined from detailed computer analysis of all Region Three lightning fires during the 1960-1974 period (Table II-6). The lightning fire density per unit area is greater in Region Three than in any other major forest region in the United States. Other studies have shown that a greater number of lightning fires in a single year have occurred in Forest Service Region One, but not the long term occurrence density found in Region Three.

Region Three has a long lightning fire season. Normally the lightning fire season begins in April and extends into October. During the 1960-1974 period, more than 99 percent of the lightning fires in the region occurred during the seven months April through October (Table II-2). A total of only 44 fires (less than 1 percent) occurred in the late fall and winter months. As explained later in this report the character of the April to early July lightning fire season is vastly different from the late summer season. The earlier months are normally characterized by dry and often windy weather.

June and July are the peak months for occurrence of lightning fires. As shown in Table II-2, two-thirds of the lightning fires occur in these two

months. During two years (1970 and 1971) more than 1000 fires have occurred in July. The peak monthly occurrence during the 1960-1974 period was 1194 in July 1971. In May 1961, the occurrence of 1039 lightning fires was the third highest single month total during the 15-year study period (Table II-3).

Average lightning fire occurrence exceeds 200 fires in some ten-day periods. As shown in Table II-4 the ten-day periods with the highest average lightning fire occurrence were as follows:

| | Period Average | Daily Average |
|---|---|---|
| June 21-30 | 230 | 23.0 |
| July 1-10 | 304 | 30.4 |
| July 11-20 | 274 | 27.4 |
| July 21-31 | 207 | 18.8 |

During the years 1960-1974, lightning fire occurrence rates of 200 or more fires in a ten-day period were recorded three times in May, thirteen in June, twenty-seven times in July and five times in August.

Average lightning fire occurrence is above 100 fires in nine consecutive monthly decades. As shown in Figure II-1 an average of more than 100 fires occur in each monthly decade from May 21-31 through August 11-20. The average occurrence is more than 200 fires for the last decade in June and each decade in July with the peak of 304 fires being reached July 1-10.

Peak lightning fire occurrence exceeds 500 fires in a ten-day period. This peak fire occurrence rate was reported on five separate ten-day periods as follows:

| | Total Fires | Daily Average |
|---|---|---|
| May 21-31, 1961 | 582 | 52.9 |
| June 21-30, 1960 | 619 | 61.9 |
| July 1-10, 1973 | 511 | 51.1 |
| July 11-20, 1970 | 629 | 52.9 |
| July 11-20, 1971 | 617 | 61.7 |

The only known lightning fire occurrence rates exceeding the above were recorded in Forest Service Region One as follows (Barrows, Sandberg and Hart, 1976):

| | Total Fires | Daily Average |
|---|---|---|
| July 1-10, 1940 | 1488 | 148.8 |
| August 21-31, 1939 | 760 | 69.0 |
| August 21-31, 1961 | 799 | 72.6 |

Table II-1. Lightning Fire Occurrence by Years in Region Three, 1940-1975.

| Year | No. of Fires | Year | No. of Fires | Year | No. of Fires | Year | No. of Fires |
|---|---|---|---|---|---|---|---|
| 1940 | 2,283 | 1950 | 1,390 | 1960 | 2,546 | 1970 | 2,200 |
| 1941 | 841 | 1951 | 1,700 | 1961 | 2,841 | 1971 | 2,351 |
| 1942 | 1,645 | 1952 | 1,063 | 1962 | 2,210 | 1972 | 2,462 |
| 1943 | 1,393 | 1953 | 1,483 | 1963 | 1,432 | 1973 | 1,647 |
| 1944 | 1,236 | 1954 | 1,751 | 1964 | 1,661 | 1974 | 2,342 |
| 1945 | 1,211 | 1955 | 782 | 1965 | 1,448 | 1975 | 1,586 |
| 1946 | 1,231 | 1956 | 2,396 | 1966 | 1,490 | | |
| 1947 | 1,318 | 1957 | 1,389 | 1967 | 1,184 | | |
| 1948 | 1,210 | 1959 | 1,678 | 1968 | 1,246 | | |
| 1949 | 1,490 | 1959 | 2,077 | 1969 | 1,305 | | |
| Total | 13,858 | | 15,709 | | 17,363 | | 12,588 |
| Average Annual Occurrence | 1,386 | | 1,571 | | 1,736 | | 2,098 |

Table II-2. Number and Percent of Lightning Fires by Months in Region Three, 1960-1974.

| | Average Annual No. of Lightning Fires | Percent of Total Lightning Fires |
|---|---|---|
| April | 14 | 0.75% |
| May | 213 | 11.24 |
| June | 460 | 24.29 |
| July | 785 | 41.48 |
| August | 298 | 15.76 |
| Sept. | 106 | 5.61 |
| Oct. | 14 | 0.71 |
| Other Months | 3 | 0.16 |
| Total Region Three | 1,893 | |

Table II-3. Lightning Fire Occurrence by Years During Peak Occurrence Months in Region Three, 1960-1974

| | May | June | July | August |
|---|---|---|---|---|
| 1960 | 572 | 902 | 778 | 213 |
| 61 | 1,039 | 937 | 560 | 214 |
| 62 | 12 | 434 | 649 | 713 |
| 63 | 56 | 144 | 766 | 394 |
| 64 | 219 | 320 | 872 | 152 |
| 65 | 88 | 196 | 834 | 266 |
| 66 | 184 | 518 | 502 | 165 |
| 67 | 164 | 243 | 697 | 61 |
| 68 | 57 | 330 | 641 | 83 |
| 69 | 195 | 199 | 505 | 322 |
| 1970 | 100 | 700 | 1,119 | 201 |
| 71 | 58 | 552 | 1,194 | 432 |
| 72 | 214 | 686 | 903 | 474 |
| 73 | 125 | 177 | 780 | 496 |
| 74 | 111 | 559 | 971 | 288 |
| Total | 3,194 | 6,897 | 11,771 | 4,475 |

Table II-4. Lightning Fire Occurrence by Ten Day Periods in Region Three National Forests, 1960-1974

| Year | 1-10 | 11-20 | 21-31[1] | 1-10 | 11-20 | 21-30 | 1-10 | 11-20 | 21-31[1] | 1-10 | 11-20 | 21-3[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 420 | 105 | 47 | 93 | 190 | 619 | 386 | 316 | 76 | 110 | 72 | 3 |
| 1961 | 13 | 444 | 582 | 284 | 285 | 368 | 229 | 138 | 193 | 128 | 52 | 3 |
| 1962 | 4 | 2 | 6 | 71 | 19 | 344 | 107 | 117 | 425 | 83 | 494 | 13 |
| 1963 | 4 | 22 | 30 | 65 | 66 | 13 | 200 | 219 | 347 | 238 | 102 | 5 |
| 1964 | 2 | 60 | 157 | 28 | 10 | 282 | 230 | 368 | 274 | 72 | 36 | 4 |
| 1965 | 2 | 58 | 28 | 58 | 25 | 113 | 368 | 379 | 87 | 90 | 133 | 4 |
| 1966 | 29 | 37 | 118 | 54 | 310 | 154 | 114 | 256 | 132 | 76 | 66 | 2 |
| 1967 | 2 | 44 | 118 | 58 | 121 | 64 | 472 | 166 | 59 | 25 | 14 | 2 |
| 1968 | 40 | 10 | 7 | 126 | 159 | 45 | 245 | 188 | 208 | 33 | 20 | 3 |
| 1969 | 10 | 98 | 87 | 146 | 45 | 8 | 159 | 230 | 116 | 183 | 79 | 6 |
| 1970 | 2 | 4 | 94 | 245 | 43 | 406 | 471 | 529 | 119 | 90 | 66 | 4 |
| 1971 | 2 | 40 | 16 | 16 | 214 | 322 | 171 | 617 | 406 | 313 | 89 | 3 |
| 1972 | 26 | 23 | 165 | 323 | 198 | 165 | 424 | 275 | 204 | 295 | 127 | 5 |
| 1973 | 2 | 88 | 35 | 37 | 36 | 104 | 511 | 115 | 154 | 90 | 287 | 11 |
| 1974 | 70 | 10 | 31 | 17 | 88 | 444 | 470 | 200 | 301 | 164 | 45 | 7 |
| Total | 628 | 1045 | 1521 | 1621 | 1809 | 3451 | 4557 | 4113 | 3101 | 1990 | 1682 | 80 |

(1) Eleven days in period

Fifty or more lightning fires frequently occur in a single day. During the 1960-1974 period there were a total of 133 days when this rate of lightning fire occurrence was reported (Table II-5). The occurrence summary is as follows:

| Year | No. of Days with 50 or More Fires |
|---|---|
| 1960 | 16 |
| 1961 | 14 |
| 1962 | 10 |
| 1963 | 4 |
| 1964 | 6 |
| 1965 | 5 |
| 1966 | 5 |
| 1967 | 6 |
| 1968 | 7 |
| 1969 | 1 |
| 1970 | 15 |
| 1971 | 14 |
| 1972 | 12 |
| 1973 | 6 |
| 1974 | 12 |
| Total | 133 |
| Annual Average | 8.87 |

Peak lightning fire occurrence is in the afternoon hours. More than 67 percent of the lightning fires occur from 1201 to 1800 hours (Figure II-2). The hours of 1801 to 2400 account for 19 percent of the fires. Less than five percent of the fires occur from 0001 to 0900 hours.

Table II-5. Dates When 50 or More Lightning Fires Occurred in Region Three, 1960-1974.

| Year | Date | No. of Fires | Year | Date | No. of Fires | Year | Date | No. of Fires |
|---|---|---|---|---|---|---|---|---|
| 1960 | 5/5 | 95 | 1964 | 5/26 | 52 | | 7/17 | 56 |
| | 5/6 | 60 | | 6/25 | 54 | | 7/18 | 103 |
| | 6/20 | 51 | | 6/27 | 53 | | 7/19 | 119 |
| | 6/22 | 67 | | 6/28 | 79 | | 7/20 | 55 |
| | 6/23 | 78 | | 7/14 | 64 | | | |
| | 6/27 | 68 | | 7/21 | 52 | 1971 | 6/16 | 63 |
| | 6/28 | 143 | | | | | 6/17 | 58 |
| | 6/29 | 62 | 1965 | 7/7 | 63 | | 6/23 | 72 |
| | 6/30 | 68 | | 7/10 | 67 | | 6/24 | 98 |
| | 7/6 | 51 | | 7/11 | 72 | | 7/13 | 76 |
| | 7/8 | 58 | | 7/12 | 64 | | 7/14 | 68 |
| | 7/9 | 63 | | 7/13 | 54 | | 7/15 | 55 |
| | 7/10 | 56 | | | | | 7/16 | 112 |
| | 7/13 | 56 | 1966 | 5/31 | 51 | | 7/17 | 87 |
| | 7/14 | 66 | | 6/14 | 53 | | 7/18 | 83 |
| | 7/15 | 55 | | 6/15 | 74 | | 7/19 | 59 |
| | | | | 6/16 | 68 | | 7/30 | 68 |
| 1961 | 5/11 | 51 | | 7/17 | 53 | | 7/31 | 56 |
| | 5/16 | 103 | | | | | 8/1 | 72 |
| | 5/17 | 93 | 1967 | 7/3 | 78 | | | |
| | 5/18 | 52 | | 7/4 | 86 | 1972 | 5/30 | 65 |
| | 5/23 | 87 | | 7/5 | 86 | | 6/1 | 52 |
| | 5/24 | 116 | | 7/6 | 50 | | 6/3 | 106 |
| | 5/25 | 91 | | 7/10 | 56 | | 6/11 | 61 |
| | 5/26 | 80 | | 7/12 | 55 | | 6/21 | 54 |
| | 5/27 | 62 | | | | | 7/5 | 75 |
| | 6/1 | 58 | 1968 | 6/3 | 53 | | 7/6 | 70 |
| | 6/14 | 64 | | 6/19 | 59 | | 7/7 | 83 |
| | 6/22 | 53 | | 7/3 | 89 | | 7/9 | 54 |
| | 6/30 | 54 | | 7/4 | 54 | | 7/16 | 57 |
| | 7/10 | 50 | | 7/19 | 63 | | 8/4 | 66 |
| | | | | 7/20 | 65 | | 8/5 | 74 |
| 1962 | 6/27 | 60 | | 7/21 | 63 | | | |
| | 6/28 | 83 | | | | 1973 | 7/3 | 57 |
| | 6/29 | 112 | 1969 | 7/4 | 50 | | 7/4 | 50 |
| | 7/23 | 77 | | | | | 7/7 | 95 |
| | 8/14 | 63 | 1970 | 6/4 | 85 | | 7/8 | 101 |
| | 8/15 | 66 | | 6/5 | 62 | | 8/13 | 50 |
| | 8/16 | 125 | | 6/6 | 52 | | 8/14 | 50 |
| | 8/17 | 60 | | 6/23 | 93 | 1974 | 6/24 | 60 |
| | 9/20 | 85 | | 6/26 | 87 | | 6/25 | 71 |
| | 9/21 | 54 | | 6/28 | 58 | | 6/27 | 58 |
| | | | | 7/7 | 104 | | 6/28 | 59 |
| 1963 | 7/19 | 63 | | 7/8 | 89 | | 6/29 | 74 |
| | 7/20 | 62 | | 7/9 | 57 | | 7/1 | 89 |
| | 7/31 | 50 | | 7/15 | 52 | | 7/2 | 91 |
| | 8/3 | 52 | | 7/16 | 96 | | 7/3 | 54 |
| | | | | | | | 7/5 | 74 |
| | | | | | | | 7/28 | 51 |
| | | | | | | | 9/3 | 50 |
| | | | | | | | 9/4 | 61 |

AVERAGE NUMBER OF LIGHTNING FIRES

BY MONTHLY DECADES IN REGION

THREE NATIONAL FORESTS, 1960 - 74

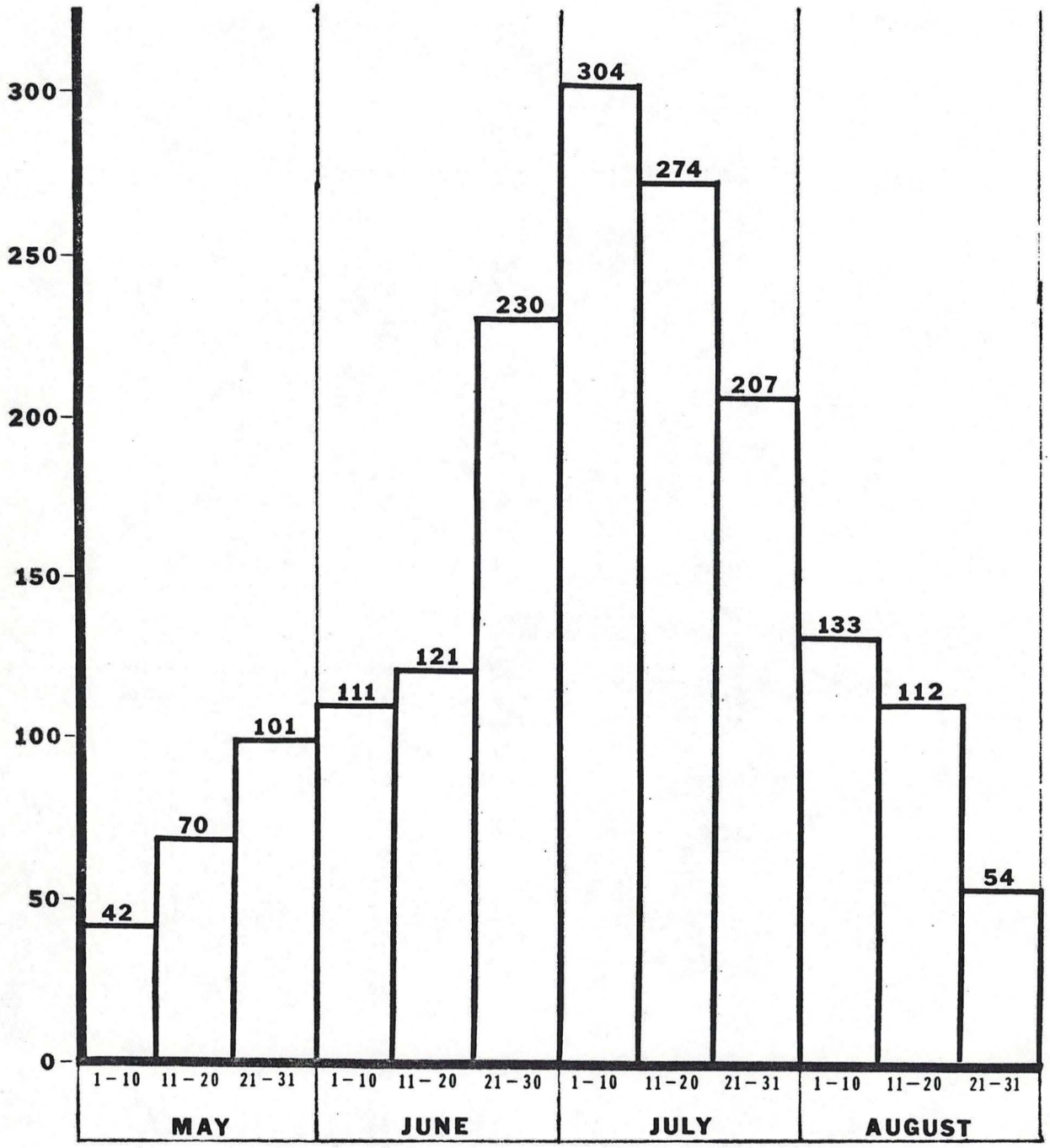


Figure II-1.

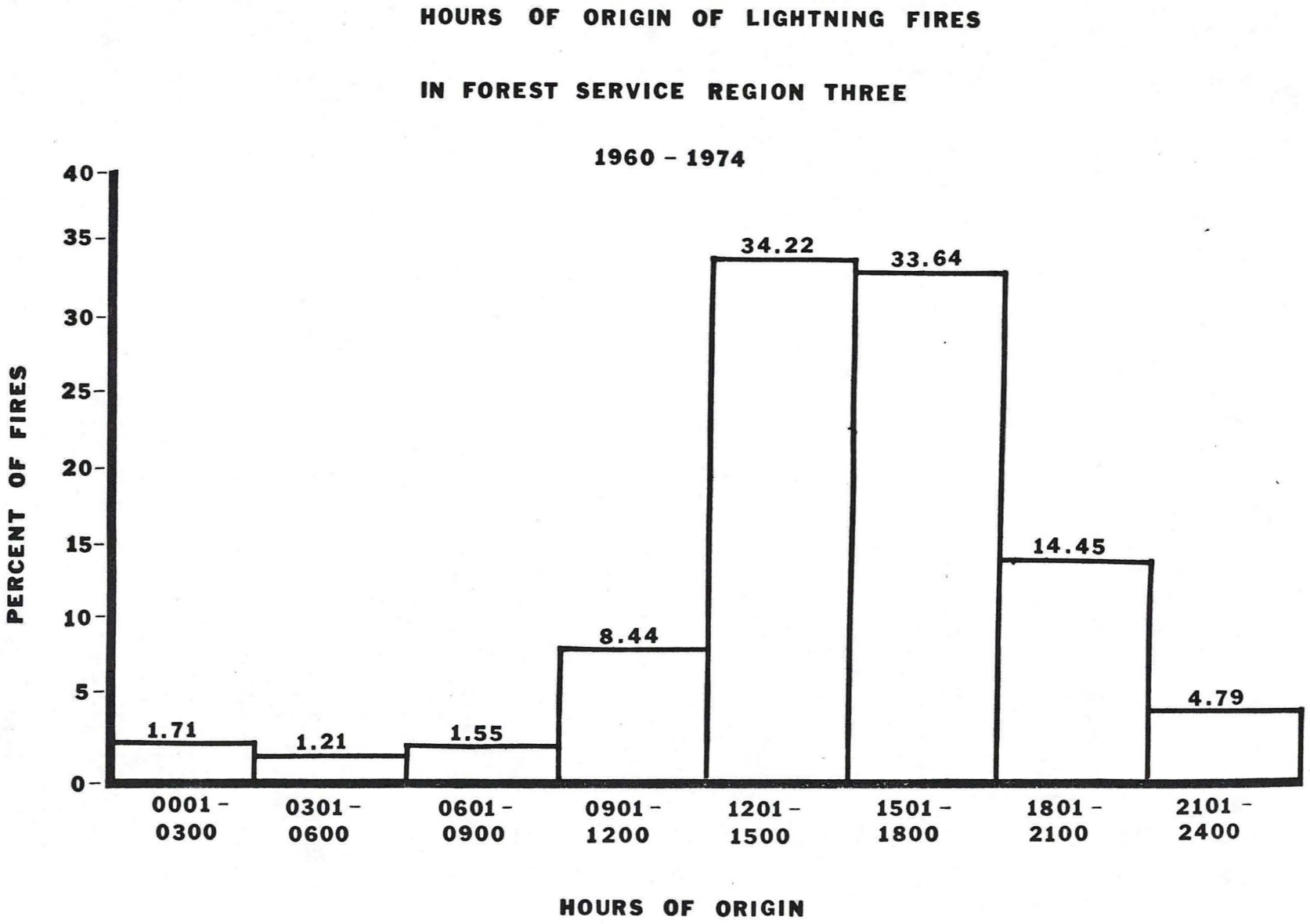
HOURS OF ORIGIN OF LIGHTNING FIRES
IN FOREST SERVICE REGION THREE
1960 - 1974
PERCENT OF FIRES
40
35
30
25
20
15
10
5
0
1.71
1.21
1.55
8.44
34.22
33.64
14.45
4.79
0001 - 0300
0301 - 0600
0601 - 0900
0901 - 1200
1201 - 1500
1501 - 1800
1801 - 2100
2101 - 2400
HOURS OF ORIGIN

Figure II-2.

## Lightning Fire Occurrence by Zones and National Forests

The Central Zone leads Region Three in lightning fire occurrence. As shown in Table II-6, the average annual occurrence of 691 fires and 124 fires per million acres in the Central Zone are the top lightning fire ignition rates in the region. For individual national forests, the Gila and Apache-Sitgreaves rank second and third respectively in lightning fire occurrence density.

The Coconino leads all individual national forests in lightning fire occurrence density. During the 1960-1974 period, the Coconino National Forest recorded an annual average of 162.63 fires per million acres (Table II-6). These occurrence density rates on the Coconino varied from a high of 301.39 in 1960 to a low of 79.57 in 1968.

Lightning fire occurrence in a single year often exceeds 700 fires in the Northwestern and Central Zones. During the 1960-1974 period these high single-year outbreaks of lightning fires have occurred 11 times in the two zones (Tables II-7 and II-8). The years with more than 700 lightning fires in each zone were as follows:

| Year | Zone | No. of Fires |
|---|---|---|
| 1960 | Northwestern | 921 |
| | Central | 934 |
| 1961 | Northwestern | 808 |
| | Central | 1254 |
| 1962 | Northwestern | 782 |
| | Central | 770 |
| 1970 | Central | 813 |
| 1971 | Central | 977 |
| 1972 | Northwestern | 870 |
| | Central | 802 |
| 1974 | Central | 835 |

Single year occurrence rates seldom exceed 400 fires in the Southwestern and Eastern Zones. These single-year rates of lightning fire occurrence have been recorded only five times in the 15-year study period (Tables II-7 and II-8). The years with more than 400 lightning fires in each zone were as follows:

| Year | Zone | No. of Fires |
|---|---|---|
| 1961 | Southwestern | 510 |
| 1962 | Southwestern | 409 |
| 1970 | Southwestern | 419 |
| 1971 | Eastern | 428 |
| 1972 | Eastern | 407 |

Table II-6. Average Annual Lightning Fire Occurrence by National Forests and Zones in Region Three, 1960-1974.

| | Area Within Unit Boundaries | Average Annual No. of Fires | Average Annual No. of Fires Per Million Acres | Fire Occurrence Ranking Forests | Zones |
|---|---|---|---|---|---|
| Kaibab | 1,600,712 | 158 | 98.71 | 4 | |
| Coconino | 2,010,733 | 327 | 162.63 | 1 | |
| Prescott | 1,407,602 | 74 | 52.57 | 9 | |
| N. W. Zone | 5,019,047 | 559 | 111.38 | | 2 |
| Coronado | 1,855,825 | 142 | 76.52 | 5 | |
| Tonto | 2,969,602 | 184 | 61.96 | 6 | |
| S. W. Zone | 4,825,427 | 326 | 67.56 | | 3 |
| Apache-Sitgreaves | 2,763,017 | 342 | 123.78 | 3 | |
| Gila | 2,797,617 | 349 | 124.75 | 2 | |
| Central Zone | 5,560,634 | 691 | 124.27 | | 1 |
| Carson | 1,491,423 | 46 | 30.84 | 11 | |
| Santa Fe | 1,719,414 | 97 | 56.41 | 7 | |
| Cibola | 2,110,844 | 105 | 49.74 | 10 | |
| Lincoln | 1,271,069 | 67 | 52.71 | 8 | |
| Eastern Zone | 6,592,750 | 315 | 47.78 | | 4 |
| Total Region Three | 21,997,585 | 1891 | 85.96 | | |

Table II-7. Lightning Fire Occurrence In Each National Forest in the Northwest and Southwest Zones, 1960-1974.

| Year | Kaibab | Coconino | Prescott | N.W. Zone | Coronado | Tonto | S.W. Zone |
|---|---|---|---|---|---|---|---|
| 1960 | 220 | 606 | 95 | 921 | 124 | 262 | 386 |
| 61 | 193 | 511 | 104 | 808 | 214 | 296 | 510 |
| 62 | 225 | 448 | 109 | 782 | 109 | 300 | 409 |
| 63 | 99 | 226 | 50 | 375 | 111 | 111 | 222 |
| 64 | 118 | 258 | 74 | 450 | 108 | 157 | 265 |
| 65 | 112 | 251 | 53 | 416 | 154 | 152 | 306 |
| 66 | 87 | 273 | 56 | 416 | 135 | 136 | 270 |
| 67 | 86 | 167 | 21 | 274 | 82 | 90 | 172 |
| 68 | 121 | 160 | 62 | 343 | 80 | 131 | 211 |
| 69 | 95 | 210 | 41 | 346 | 138 | 135 | 273 |
| 70 | 182 | 346 | 102 | 630 | 195 | 224 | 419 |
| 71 | 221 | 346 | 74 | 641 | 157 | 148 | 305 |
| 72 | 283 | 464 | 123 | 870 | 174 | 209 | 383 |
| 73 | 140 | 269 | 57 | 466 | 167 | 203 | 370 |
| 74 | 187 | 368 | 90 | 645 | 185 | 213 | 398 |
| Total | 2369 | 4903 | 1111 | 8383 | 2132 | 2767 | 4899 |

Table II-8. Lightning Fire Occurrence In Each National Forest in the Central and Eastern Zones, 1960-1974.

| | Apache-Sitgreaves | Gila | Central Zone | Carson | Santa Fe | Cibola | Lincoln | Easter Zone |
|---|---|---|---|---|---|---|---|---|
| 1960 | 495 | 439 | 934 | 52 | 108 | 86 | 59 | 305 |
| 61 | 596 | 658 | 1254 | 44 | 71 | 86 | 68 | 269 |
| 62 | 418 | 352 | 770 | 27 | 89 | 86 | 47 | 249 |
| 63 | 256 | 288 | 544 | 60 | 92 | 103 | 36 | 291 |
| 64 | 252 | 315 | 567 | 44 | 118 | 129 | 88 | 379 |
| 65 | 223 | 244 | 467 | 33 | 56 | 107 | 63 | 259 |
| 66 | 267 | 207 | 474 | 44 | 99 | 127 | 60 | 330 |
| 67 | 190 | 245 | 435 | 42 | 114 | 87 | 60 | 303 |
| 68 | 233 | 233 | 466 | 26 | 75 | 76 | 49 | 226 |
| 69 | 180 | 259 | 439 | 34 | 69 | 76 | 68 | 247 |
| 1970 | 421 | 392 | 813 | 37 | 67 | 134 | 100 | 338 |
| 71 | 554 | 418 | 977 | 76 | 151 | 123 | 78 | 428 |
| 72 | 415 | 387 | 802 | 57 | 132 | 148 | 70 | 407 |
| 73 | 322 | 261 | 583 | 48 | 58 | 83 | 39 | 228 |
| 74 | 304 | 531 | 835 | 64 | 155 | 120 | 125 | 464 |
| Total | 5131 | 5229 | 10360 | 688 | 1454 | 1571 | 1010 | 4723 |

Single-year occurrence of 300 or more fires has been recorded on four national forests. As shown in Tables II-7 and II-8, this single-year lightning fire ignition rate has occurred eight times on both the Apache-Sitgreaves and Gila, seven times on the Coconino and once on the Tonto. The peak single-year ignitions were 658 fires on the Gila in 1961 and 606 fires on the Coconino in 1960. On the other extreme the peak single-year occurrence on the Carson was 64 fires in 1974.

Average annual lightning fire occurrence is highest in July in all zones. A monthly summary of lightning fire occurrence by years in each zone is presented in Tables II-9 through II-12. The peak July occurrence was 437 fires in the Northwestern Zone in 1971. During July 1971 and 1975, the Central Zone recorded 405 fires. The percent of lightning fires occurring during July in each zone is as follows:

| | |
|---|---|
| Northwestern Zone | 39.82% |
| Southwestern Zone | 47.78 |
| Central Zone | 42.30 |
| Eastern Zone | 36.08 |

The Central and Eastern Zones have a high proportion of lightning fires in May and June. As shown in Tables II-11 and II-12, the percent of lightning fires in these early season months was 42.92 in the Central Zone and 46.26 in the Eastern Zone. The largest number of lightning fires in any month was 459 recorded in the Central Zone in 1961.

The Northwestern Zone has a high proportion of late season lightning fires. During the 1960-1974 period nearly 34 percent of the lightning fires in the zone occurred in August and September. The peak occurrence during these months was 485 fires in the Northwestern Zone in 1962.

On four national forests in the Northwestern and Central Zones, 25 or more lightning fires have occurred in a single day. As shown in Table II-13, there were 57 occasions with this rate of single-day fire occurrence in the Kaibab, Coconino, Apache-Sitgreaves and Gila National Forests. The peak single-day occurrence was 57 lightning fires in the Coconino on June 28, 1960. The number of days with 25 or more fires in each of the national forests and zones was as follows:

| | No. of days |
|---|---|
| Kaibab National Forest | 4 |
| Coconino National Forest | 16 |
| Northwestern Zone Total | 20 |
| | |
| Apache-Sitgreaves National Forest | 14 |
| Gila National Forest | 23 |
| Central Zone Total | 37 |

Table II-9. Number of Lightning Fires by Months, Northwestern Zone, 1960-1974

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other Months | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 19 | 133 | 411 | ]96 | 51 | 4 | 2 | 5 | 921 |
| 1961 | 2 | 217 | 145 | 245 | 171 | 21 | 2 | 5 | 808 |
| 62 | 2 | 5 | 75 | 205 | 261 | 224 | 9 | 0 | 781 |
| 63 | 0 | 3 | 31 | 128 | 169 | 31 | 13 | 0 | 375 |
| 64 | 2 | 7 | 114 | 202 | 67 | 50 | 8 | 0 | 450 |
| 65 | | 8 | 65 | 167 | 156 | 17 | 3 | | 416 |
| 66 | 13 | 40 | 104 | 143 | 67 | 35 | 10 | 4 | 416 |
| 67 | | 32 | 26 | 180 | 28 | 8 | 1 | 0 | 275 |
| 68 | 5 | 24 | 12 | 218 | 43 | 36 | 5 | 0 | 343 |
| 69 | 1 | 27 | 38 | 107 | 129 | 41 | 3 | 0 | 346 |
| 70 | | 11 | 95 | 387 | 102 | 20 | 11 | 4 | 630 |
| 71 | 1 | 12 | 4 | 437 | 172 | 14 | | 1 | 641 |
| 72 | | 68 | 216 | 213 | 237 | 135 | 1 | | 870 |
| 73 | | 35 | 24 | 179 | 218 | 7 | 3 | | 466 |
| 74 | 1 | 13 | 31 | 231 | 124 | 205 | 40 | 0 | 645 |
| Total | 46 | 635 | 1391 | 3338 | 1995 | 848 | 111 | 19 | 8383 |
| Percent | 0.55 | 7.62 | 17.18 | 39.82 | 23.80 | 10.11 | 0.74 | 0.18 | |

Table II-10. Number of Lightning Fires by Months, Southwestern Zone, 1960-1974

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 3 | 83 | 145 | 123 | 29 | 7 | | | 390 |
| 61 | 1 | 184 | 240 | 82 | 2 | 4 | | | 513 |
| 62 | 2 | | 93 | 124 | 141 | 46 | 3 | | 409 |
| 63 | 1 | 1 | 2 | 142 | 70 | 5 | 2 | | 222 |
| 64 | 1 | 2 | 73 | 166 | 14 | 8 | 2 | | 266 |
| 65 | 2 | 5 | 20 | 221 | 50 | 5 | 1 | 1 | 308 |
| 66 | 6 | 3 | 74 | 125 | 53 | 7 | | 1 | 269 |
| 67 | | 28 | 22 | 110 | 9 | 3 | | 1 | 173 |
| 68 | 3 | 4 | 13 | 148 | 20 | 20 | 3 | | 211 |
| 69 | 1 | 26 | 10 | 111 | 108 | 18 | | | 274 |
| 70 | | 6 | 59 | 302 | 47 | 5 | 1 | | 420 |
| 71 | 1 | 4 | 39 | 175 | 63 | 25 | | | 307 |
| 72 | | 21 | 122 | 154 | 66 | 19 | | 1 | 383 |
| 73 | | 14 | 34 | 198 | 113 | 9 | 2 | | 370 |
| 74 | 1 | 13 | 91 | 166 | 50 | 76 | 4 | | 397 |
| Total | 21 | 394 | 1037 | 2347 | 835 | 257 | 18 | 4 | 4912 |
| Percent | 0.43 | 8.02 | 21.17 | 47.78 | 17.00 | 5.23 | 0.29 | 0.08 | |

Table II-11. Number of Lightning Fires by Months, Central Zone. 1960-1974

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 8 | 266 | 273 | 284 | 98 | 4 | | | 933 |
| 61 | 8 | 541 | 459 | 201 | 37 | 7 | | 1 | 1254 |
| 62 | 2 | 1 | 199 | 245 | 239 | 80 | 3 | 1 | 770 |
| 63 | 1 | 12 | 43 | 389 | 88 | 7 | 4 | | 544 |
| 64 | 2 | 124 | 79 | 329 | 27 | 3 | 3 | | 567 |
| 65 | 6 | 33 | 57 | 324 | 35 | 8 | 4 | | 467 |
| 66 | 16 | 68 | 208 | 155 | 17 | 7 | 2 | 1 | 474 |
| 67 | | 49 | 99 | 283 | 3 | 1 | 1 | | 436 |
| 68 | 1 | 15 | 223 | 177 | 6 | 28 | 17 | | 467 |
| 69 | 6 | 90 | 76 | 195 | 64 | 7 | 1 | | 439 |
| 70 | 4 | 38 | 429 | 295 | 26 | 21 | 2 | 1 | 814 |
| 71 | 14 | 17 | 328 | 405 | 163 | 50 | | 3 | 980 |
| 72 | | 67 | 214 | 389 | 107 | 24 | 1 | | 802 |
| 73 | | 61 | 75 | 305 | 109 | 26 | 7 | | 583 |
| 74 | 1 | 36 | 267 | 405 | 60 | 62 | 6 | | 842 |
| Total | 69 | 1418 | 3029 | 4386 | 1079 | 335 | 51 | 7 | 10372 |
| Percent | 0.66 | 13.68 | 29.24 | 42.30 | 10.41 | 3.23 | 0.49 | 0.07 | |

Table II-12. Number of Lightning Fires By Months, Eastern Zone, 1960-1974

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 13 | 90 | 73 | 75 | 36 | 12 | 1 | 5 | 305 |
| 61 | 35 | 97 | 93 | 32 | 4 | 4 | | 3 | 268 |
| 62 | 4 | 6 | 67 | 75 | 72 | 23 | 2 | | 249 |
| 63 | 1 | 40 | 68 | 107 | 67 | 8 | 2 | | 293 |
| 64 | 3 | 86 | 54 | 175 | 44 | 15 | 1 | 1 | 379 |
| 65 | 3 | 42 | 51 | 122 | 25 | 14 | 3 | | 260 |
| 66 | 4 | 73 | 132 | 79 | 28 | 11 | 2 | 1 | 330 |
| 67 | 1 | 55 | 96 | 124 | 21 | 5 | | 1 | 303 |
| 68 | | 14 | 82 | 98 | 14 | 10 | 8 | | 226 |
| 69 | | 52 | 75 | 92 | 21 | 7 | | | 247 |
| 70 | | 45 | 117 | 136 | 26 | 12 | 2 | | 338 |
| 71 | | 25 | 182 | 177 | 34 | 6 | | 2 | 428 |
| 72 | | 58 | 134 | 147 | 64 | 4 | 1 | | 408 |
| 73 | 1 | 15 | 44 | 98 | 56 | 10 | 4 | | 228 |
| 74 | 11 | 49 | 170 | 169 | 54 | 12 | 3 | 1 | 466 |
| Total | 78 | 747 | 1438 | 1706 | 566 | 153 | 26 | 14 | 4728 |
| Percent | 1.65 | 15.80 | 30.46 | 36.08 | 11.97 | 3.23 | 0.51 | 0.30 | |

Table II-13. Dates of Occurrence of 25 or More Lightning Fires in Individual National Forests, 1960-1974.

| Year | Date | National Forest | No. of Fires |
|---|---|---|---|
| 1960 | 5-5 | Gila | 29 |
| | 6-27 | Coconino | 28 |
| | 6-28 | Apache-Sitgreaves | 27 |
| | 6-28 | Coconino | 57 |
| | 6-28 | Kaibab | 30 |
| | 6-29 | Coconino | 32 |
| | 7-9 | Coconino | 28 |
| | 7-14 | Coconino | 26 |
| 1961 | 5-11 | Gila | 26 |
| | 5-16 | Gila | 40 |
| | 5-17 | Gila | 27 |
| | 5-17 | Coconino | 30 |
| | 5-24 | Coconino | 30 |
| | 5-24 | Apache-Sitgreaves | 28 |
| | 5-26 | Apache-Sitgreaves | 30 |
| | 5-27 | Apache-Sitgreaves | 26 |
| | 6-1 | Gila | 32 |
| | 6-22 | Apache-Sitgreaves | 25 |
| 1962 | 6-29 | Gila | 39 |
| | 8-15 | Kaibab | 25 |
| | 8-16 | Coconino | 33 |
| | 9-21 | Coconino | 25 |
| 1964 | 5-26 | Gila | 33 |
| 1965 | 7-13 | Gila | 26 |
| 1966 | 6-14 | Apache-Sitgreaves | 27 |
| 1967 | 7-4 | Gila | 26 |
| 1968 | 6-19 | Gila | 29 |
| 1970 | 6-4 | Gila | 27 |
| | 6-21 | Gila | 25 |
| | 6-23 | Apache-Sitgreaves | 46 |
| | 6-26 | Apache-Sitgreaves | 36 |
| | 6-26 | Gila | 33 |
| | 6-27 | Gila | 28 |
| | 7-7 | Coconino | 30 |
| | 7-16 | Kaibab | 26 |
| | 7-18 | Apache-Sitgreaves | 36 |
| | 7-19 | Gila | 30 |
| 1971 | 6-17 | Apache-Sitgreaves | 32 |
| | 6-23 | Gila | 37 |
| | 6-24 | Gila | 38 |
| | 6-24 | Apache-Sitgreaves | 31 |
| | 7-13 | Apache Sitgreaves | 26 |
| | 7-14 | Coconino | 34 |
| | 7-16 | Coconino | 25 |
| | 7-16 | Apache-Sitgreaves | 31 |
| | 7-17 | Kaibab | 26 |
| 1972 | 6-21 | Coconino | 25 |
| | 7-16 | Gila | 26 |
| | 8-4 | Coconino | 35 |
| 1973 | 7-7 | Apache-Sitgreaves | 3 |
| 1974 | 6-27 | Gila | 3 |
| | 6-28 | Gila | 36 |
| | 7-1 | Gila | 2 |
| | 7-2 | Gila | 55 |
| | 7-3 | Gila | 3 |
| | 9-3 | Coconino | 26 |
| | 9-4 | Coconino | 2 |

## II-2. Size Class of Fires and Area Burned

### Size Class

More than three-fourths of the lightning fires in Region Three are less than one-fourth acre in size. During the 36-year period 1940-1975, a total of 46,389 Class A lightning fires occurred in Region Three national forests (Table II-14). This was 77.94 percent of the total lightning fires. These fires, while small, are a definite factor in the overall fire load. While specific data is lacking on personnel requirements for Class A fires, experience indicates that an average of 2 to 3 personnel and 1 to 2 days are required per fire (including travel, suppression and mop up). With an annual average of 1289 class A fires during the 1940-1975 period, this amounts to 2578 to 7734 personnel days per fire season. These estimates may be higher for recent years because the annual average number of class A lightning fires increased to 1626 during the 1970-1975 period.

Nearly one-fourth of the lightning fires exhibit growth potential. During the 36-year study period, an annual average of 365 fires reached sizes of one-fourth acre or more (22.06 percent of total). It is recognized that many Class A fires also have growth potential, but are prevented from significant growth by efficient control action. The Class B and larger fires clearly demonstrate some potential for growth. The average annual number and percent of Class B or larger lightning fires in each decade was recorded as follows:

| Years | Average Annual Number | Percent of Total Fires |
|---|---|---|
| 1940-1949 | 357 | 25.78 |
| 1950-1959 | 364 | 23.17 |
| 1960-1969 | 309 | 17.79 |
| 1970-1975 | 471 | 22.47 |

Slightly less than three percent of the lightning fires in Region Three reach Class C or larger size. As shown in Table II-14, the percent of Class C or larger fires varied from a low of 2.59 percent in the sixties decade to a high of 3.36 percent in the seventies. The 36-year average is 2.97 percent. This is a remarkable record of fire control efficiency. During three years (1941, 1958, 1963) not more than 20 fires reached Class C or larger size. The greatest number in a single year was 149 fires in 1974.

An average of 10 fires per year reach Class D or larger size. As explained later in this report, these fires have a great impact on the total fire load. During the 1940-1975 period, a total of 372 Class D or larger fires occurred.

More than 42 percent of these big fires occurred in just seven years (1943, 1956, 1960, 1961, 1969, 1971 and 1974) with the peak of 32 fires being recorded in 1974 (Table II-14). The average annual number and percent of fires reaching Class D or larger size in each decade was as follows:

| Years | Average Annual Number | Percent of Total Fires |
|---|---|---|
| 1940-1949 | 8 | 0.56 |
| 1950-1959 | 9 | 0.55 |
| 1960-1969 | 12 | 0.70 |
| 1970-1975 | 14 | 0.69 |

Lightning fires reaching 100 acres in size have a high potential for continued growth. This potential is vividly illustrated by the large fires in Region Three during the 1960-1974 periods (Table II-5):

(1) Of the fires reaching Class D size, 51.78 percent continued on to Class E or larger size.

(2) Of the fires reaching Class E size, 47.06 percent continued on to Class F or larger size.

(3) Of the fires reaching Class F size, 35.42 percent continued on to Class G size.

Expressed as betting odds, these data show:

(1) When a fire becomes 100 acres in size, the odds are better than 1 to 1 that it will burn more than 300 acres.

(2) When a fire becomes 300 acres in size, the odds are about 5 to 6 that it will burn more than 1000 acres.

(3) When a fire becomes 1000 acres in size, the odds are about 1 to 2 that it will burn more than 5000 acres.

The importance of holding fires to less than 10 acres in size should also be noted. During the 1960-1974 period, 24 percent of the fires reaching Class C size continued on to Class D or larger size (odds of 1 to 4).

The Southwestern Zone has the greatest number and percent of Class C or larger lightning fires. During the 1960-1974 period, 408 class C or larger fires occurred. This was 8.33 percent of the lightning fires in the zone (Tables II-15 and II-16). The Southwestern Zone also had the largest number of Class D, E, F and G fires. The Coronado and Tonto national forests rank first and second respectively in Region Three in total number and percent of lightning fires in size classes C through F. Both national forests recorded four class G fires to lead the region in this category (Table II-15).

The Northwestern Zone has the smallest number and percent of Class C or larger lightning fires. Exhibiting a remarkable difference from other zones the Northwestern Zone recorded only 57 class C or larger fires during the 15-year period 1960-1974 (Table II-16). This is only 0.68 percent of the total lightning fires in the zone. Only the Carson National Forest in the Eastern Zone recorded a smaller number of class C or larger fires than the Kaibab, Coconino or Prescott national forests in the Northwestern Zone. Both the Central and Eastern Zones exceed the Northwestern Zone in number and percent of Class D or larger fires.

Table II-14. Lightning Fires by Size Class in Region Three, 1940-1975

| Year | No. of Fires by Size Class A | B | C | D | E+(1) | Total | % Class C or larger | No. of Class D or larger |
|---|---|---|---|---|---|---|---|---|
| 1940 | 1877 | 382 | 21 | 2 | 1 | 2283 | | 3 |
| 41 | 723 | 114 | 4 | 0 | 0 | 841 | | 0 |
| 42 | 1263 | 350 | 27 | 3 | 2 | 1645 | | 5 |
| 43 | 942 | 384 | 48 | 11 | 8 | 1393 | | 18 |
| 44 | 898 | 291 | 39 | 3 | 5 | 1236 | | 8 |
| 45 | 882 | 289 | 34 | 2 | 4 | 1211 | | 6 |
| 46 | 856 | 317 | 44 | 5 | 9 | 1231 | | 14 |
| 47 | 896 | 364 | 49 | 4 | 5 | 1318 | | 9 |
| 48 | 827 | 344 | 32 | 4 | 3 | 1210 | | 7 |
| 49 | 1122 | 320 | 42 | 5 | 1 | 1490 | | 6 |
| Total | 10286 | 3155 | 340 | 39 | 38 | 13858 | 3.02 | 77 |
| 1950 | 985 | 344 | 49 | 9 | 3 | 1320 | | 12 |
| 51 | 1299 | 357 | 39 | 1 | 4 | 1700 | | 5 |
| 52 | 792 | 241 | 27 | 3 | 0 | 1063 | | 3 |
| 53 | 1111 | 310 | 51 | 7 | 4 | 1483 | | 11 |
| 54 | 1280 | 401 | 63 | 4 | 3 | 1751 | | 7 |
| 55 | 597 | 157 | 23 | 3 | 2 | 782 | | 5 |
| 56 | 1704 | 588 | 73 | 13 | 18 | 2396 | | 31 |
| 57 | 1085 | 273 | 25 | 2 | 4 | 1389 | | 6 |
| 58 | 1447 | 211 | 18 | 0 | 2 | 1678 | | 2 |
| 59 | 1770 | 279 | 24 | 0 | 4 | 2077 | | 4 |
| Total | 12070 | 3261 | 392 | 42 | 44 | 15709 | 3.02 | 86 |
| 1960 | 2133 | 356 | 40 | 3 | 14 | 2546 | | 17 |
| 61 | 2388 | 395 | 42 | 10 | 6 | 2841 | | 16 |
| 62 | 1921 | 259 | 22 | 5 | 3 | 2210 | | 8 |
| 63 | 1286 | 134 | 8 | 2 | 2 | 1432 | | 4 |
| 64 | 1414 | 212 | 24 | 9 | 2 | 1661 | | 11 |
| 65 | 1183 | 211 | 43 | 3 | 8 | 1448 | | 11 |
| 66 | 1120 | 318 | 41 | 5 | 6 | 1490 | | 11 |
| 67 | 959 | 198 | 19 | 2 | 6 | 1184 | | 8 |
| 68 | 948 | 254 | 31 | 7 | 6 | 1246 | | 13 |
| 69 | 922 | 302 | 58 | 14 | 9 | 1305 | | 23 |
| Total | 14274 | 2639 | 328 | 60 | 62 | 17363 | 2.59 | 122 |
| 1970 | 1646 | 483 | 56 | 4 | 11 | 2200 | | 15 |
| 71 | 1721 | 551 | 59 | 8 | 12 | 2351 | | 20 |
| 72 | 2096 | 339 | 24 | 2 | 1 | 2462 | | 3 |
| 73 | 1293 | 309 | 40 | 4 | 1 | 1647 | | 5 |
| 74 | 1747 | 466 | 117 | 17 | 15 | 2362 | | 32 |
| 75 | 1276 | 257 | 41 | 5 | 7 | 1586 | | 12 |
| Total | 9759 | 2405 | 337 | 40 | 47 | 12608 | 3.36 | 87 |
| Grand Total | 46389 | 11460 | 1397 | 181 | 191 | 59539 | 2.97 | 372 |

(1) Class E or larger

Table II-15. Distribution of Lightning Fires By Size Class in Each National Forest and Zone, 1960-1974

| | A | B | C | D | E | F | G | Total |
|---|---|---|---|---|---|---|---|---|
| Northwest Zone | | | | | | | | |
| Kaibab | 2078 | 277 | 10 | 1 | 1 | 0 | 2 | 2369 |
| Coconino | 4361 | 523 | 12 | 5 | 1 | 1 | 0 | 4903 |
| Prescott | 962 | 125 | 19 | 4 | 1 | 0 | 0 | 1111 |
| Zone Total | 7401 | 925 | 41 | 10 | 3 | 1 | 2 | 8383 |
| Zone % | | | | | | | | |
| Southwest Zone | | | | | | | | |
| Coronado | 1424 | 455 | 175 | 30 | 30 | 14 | 4 | 2132 |
| Tonto | 2086 | 526 | 117 | 22 | 8 | 4 | 4 | 2767 |
| Zone Total | 3510 | 981 | 292 | 52 | 38 | 18 | 8 | 4899 |
| Zone % | | | | | | | | |
| Central Zone | | | | | | | | |
| Apache-Sitgreaves | 4063 | 958 | 91 | 10 | 2 | 4 | 3 | 5131 |
| Gila | 4014 | 1093 | 106 | 8 | 5 | 1 | 2 | 5229 |
| Zone Total | 8077 | 2051 | 197 | 18 | 7 | 5 | 5 | 10360 |
| Zone % | | | | | | | | |
| Eastern Zone | | | | | | | | |
| Carson | 544 | 138 | 6 | 0 | 0 | 0 | 0 | 688 |
| Santa Fe | 1180 | 239 | 30 | 1 | 1 | 3 | 1 | 1455 |
| Cibola | 1203 | 311 | 41 | 9 | 3 | 3 | 0 | 1570 |
| Lincoln | 842 | 142 | 17 | 5 | 2 | 1 | 1 | 1010 |
| Zone Total | 3769 | 830 | 94 | 15 | 6 | 7 | 2 | 4723 |
| Zone % | | | | | | | | |
| Region Three | | | | | | | | |
| No. of Fires | 22757 | 4787 | 624 | 95 | 54 | 31 | 17 | 28365 |
| % | 80.23 | 16.88 | 2.20 | 0.33 | 0.o9 | 0.11 | 0.06 | |

## Average Size Per Fire

Lightning fires in Region Three have an average size of nearly 13 acres. Great variation in fire size exists between zones and individual national forests. The smallest average size per fire (2.87 acres) is in the Northwestern Zone and the largest (32.12 acres) is in the Southwestern Zone (Table II-16). Average fire size exceeds 20 acres in the Coronado, Tonto and Lincoln National Forests, while the average is less than two acres in the Carson, Coconino and Prescott. The extremes are 0.42 acres in the Carson and 44.41 acres in the Coronado.

The average size per lightning fire is increasing. As shown in Table II-17 the average size per lightning fire has increased in every decade of the study period. The average fire size to date during the seventies decade is more than double that of the forties decade. The reasons for the steady increase in fire size is not clearly understood although very large fires in 1971 and 1974 strongly influence the average for the seventies decade. This is countered by an increase in number of lightning fires. The summary data for each decade are as follows:

| Years | No. of Fires | Acres Burned | Acres Per Fire |
|---|---|---|---|
| 1940-1949 | 13,858 | 101,266 | 7.31 |
| 1950-1959 | 15,709 | 131,846 | 8.39 |
| 1960-1969 | 17,363 | 167,733 | 9.66 |
| 1970-1975 | 12,588 | 215,890 | 17.15 |

Table II-16. Average Size and Percent of Lightning Fires Reaching Class C or Larger Size in Each National Forest and Zone. 1960-1974.

| Forest and Zone | Average Size Per Fire (Acres) | No. of Class C or Larger Fires | Percent of Fires Reaching Class C or Larger Size |
|---|---|---|---|
| Kaibab | 7.83 | 14 | 0.59% |
| Coconino | 0.72 | 19 | 0.39 |
| Prescott | 1.80 | 24 | 2.16 |
| N. W. Zone | 2.87 | 57 | 0.68 |
| Coronado | 44.41 | 253 | 11.87 |
| Tonto | 22.66 | 155 | 5.60 |
| S. W. Zone | 32.12 | 408 | 8.33 |
| Apache-Sitgreaves | 16.90 | 110 | 2.14 |
| Gila | 8.48 | 122 | 2.33 |
| Central Zone | 12.65 | 232 | 2.24 |
| Carson | 0.42 | 6 | 0.87 |
| Santa Fe | 13.74 | 36 | 2.47 |
| Cibola | 6.03 | 56 | 3.57 |
| Lincoln | 21.92 | 26 | 2.57 |
| Eastern Zone | 10.99 | 124 | 2.63 |
| Total Region Three | 12.85 | 821 | 2.89 |

## Area Burned

Lightning fires burned more than 616,000 acres in Region Three in 36 years. As shown in Table II-17, the area burned has been steadily increasing. More than 30,000 acres were burned in seven of the years studied (1946, 1951, 1956, 1959, 1960, 1971, and 1974). Less than 2000 acres were burned in three years (1941, 1953 and 1958). The average annual area burned in the region was 17,131 acres during the 1940-1975 period. The peak area burned in a single year was 96,661 acres in 1971.

The area burned by lightning fires has increased in each decade. During the forties decade the average annual area burned by lightning fires in Region Three was 10,127 acres (Table II-17). The area burned has increased in each decade since the forties culminating in an annual average of 35,982 acres durting the 1970-1975 period. Gaining an understanding of this steady increase in area burned requires analyses of several factors including fuel flammability, fire control methods and the magnitude of the total fire load in the region. These factors are summarized in later sections of the report.

The largest area burned by lightning fires is in the Southwestern Zone. As shown in Table II-18 more than 157,000 acres were burned in the Southwestern Zone during the 1960-1974 period. This is 43 percent of the area burned by lightning fires in Region Three and is more than double the area burned in the combined Northwestern and Eastern zones. The Central Zone ranks second in area burned with more than 131,000 acres during the 1960-1974 period. The Central Zone had the greatest burn in a single year with 76,937 acres in 1971.

The Coronado and Apache-Sitgreaves National Forests lead Region Three in total area burned by lightning fires. During the 1960-1974 period the Coronado burn was 94,686 acres and the Apache-Sitgreaves 86,736 acres to rank these forests first and second respectively in area burned by lightning fires. This amounts to 49.78 percent of the total area burned by lightning fires in Region Three during the 15 year study period. It should be noted that 87 percent of the area burned in the Apache-Sitgreaves National Forest occurred in a single year - 1971. On the other hand, the Coronado had burns of more than 10,000 acres during five years and less than 500 acres in only one year. A summary of area burned by years in each national forest in Region Three is presented in Tables II-19 and II-20.

Table II-17. Acres Burned by Lightning Fires by Years in Region Three, 1940-1975.

| Year | Acres Burned | Year | Acres Burned | Year | Acres Burned | Year | Acres Burned |
|---|---|---|---|---|---|---|---|
| 1940 | 2220 | 1950 | 5310 | 1960 | 31490 | 1970 | 21776 |
| 41 | 383 | 51 | 34117 | 61 | 16421 | 71 | 96661 |
| 42 | 3068 | 52 | 2077 | 62 | 13848 | 72 | 3799 |
| 43 | 11314 | 53 | 1483 | 63 | 3928 | 73 | 2110 |
| 44 | 9741 | 54 | 4548 | 64 | 9512 | 74 | 72334 |
| 45 | 3961 | 55 | 3366 | 65 | 17127 | 75 | 19210 |
| 46 | 35447 | 56 | 41743 | 66 | 27525 | | |
| 47 | 18004 | 57 | 5554 | 67 | 7774 | | |
| 48 | 13905 | 58 | 1522 | 68 | 28836 | | |
| 49 | 3223 | 59 | 32126 | 69 | 11272 | | |
| Total | 101266 | | 131846 | | 167733 | | 215890 |
| Annual Average | 10127 | | 13185 | | 16773 | | 35982 |
| Ave. Size Per Fire | 7.31 | | 8.39 | | 9.66 | | 17.15 |

Table II-18. Acres Burned by Lightning Fires in Region Three and in Each Zone, 1960-1974.

| Year | N. W. Zone | S. W. Zone | Central Zone | Eastern Zone | Total R-3 |
|---|---|---|---|---|---|
| 1960 | 9637 | 15095 | 5370 | 1388 | 31490 |
| 61 | 611 | 13641 | 1002 | 1167 | 16421 |
| 62 | 8817 | 2435 | 784 | 1812 | 13848 |
| 63 | 50 | 317 | 267 | 3294 | 3928 |
| 64 | 772 | 6691 | 1012 | 1037 | 9512 |
| 65 | 95 | 15539 | 455 | 1038 | 17127 |
| 66 | 779 | 24745 | 1090 | 911 | 27525 |
| 67 | 1954 | 1031 | 4264 | 525 | 7774 |
| 68 | 262 | 24925 | 3322 | 327 | 28836 |
| 69 | 240 | 7872 | 2559 | 601 | 11272 |
| 1970 | 77 | 18209 | 3235 | 255 | 21776 |
| 71 | 273 | 3996 | 76937 | 15455 | 96661 |
| 72 | 116 | 684 | 98 | 2901 | 3799 |
| 73 | 36 | 1720 | 120 | 234 | 2110 |
| 74 | 359 | 20474 | 30555 | 20946 | 72334 |
| Total | 24078 | 157374 | 131070 | 51891 | 364413 |

Table II-19. Acres Burned by Lightning Fires in the National Forests of the Northwest and Southwest Zones, 1960-1974.

| Year | Kaibab | Coconino | Prescott | N. W. Zone | Coronado | Tonto | S. W. Zone |
|---|---|---|---|---|---|---|---|
| 1960 | 8760 | 51 | 826 | 9637 | 14671 | 424 | 15095 |
| 61 | 302 | 199 | 110 | 611 | 12729 | 912 | 13641 |
| 62 | 8716 | 15 | 86 | 8817 | 1798 | 637 | 2435 |
| 63 | 20 | 28 | 2 | 50 | 247 | 70 | 317 |
| 64 | 61 | 303 | 408 | 772 | 1143 | 5548 | 6691 |
| 65 | 23 | 40 | 32 | 95 | 12434 | 3105 | 15539 |
| 66 | 517 | 53 | 209 | 779 | 3498 | 21247 | 24745 |
| 67 | 22 | 1908 | 24 | 1954 | 769 | 262 | 1031 |
| 68 | 14 | 239 | 9 | 262 | 24825 | 100 | 24925 |
| 69 | 44 | 57 | 139 | 240 | 5129 | 2743 | 7872 |
| 1970 | 0 | 65 | 12 | 77 | 2609 | 15600 | 18209 |
| 71 | 0 | 253 | 20 | 273 | 3507 | 489 | 3996 |
| 72 | 20 | 50 | 46 | 116 | 634 | 50 | 684 |
| 73 | 16 | 0 | 20 | 36 | 500 | 1220 | 1720 |
| 74 | 32 | 270 | 57 | 359 | 10193 | 10281 | 20474 |
| Total | 18547 | 3531 | 2000 | 24078 | 94686 | 62688 | 157374 |
| An Ave. | 1236 | 235 | 133 | 1605 | 6312 | 4179 | 10492 |

Table II-20. Acres Burned by Lightning Fires in the National Forests of the Central and Eastern Zones, 1960-1974.

| Year | Apache-Sitgreaves | Gila | Central Zone | Carson | Santa Fe | Cibola | Lincoln | Eastern Zone |
|---|---|---|---|---|---|---|---|---|
| 1960 | 182 | 5188 | 5370 | 20 | 418 | 19 | 931 | 1388 |
| 61 | 657 | 345 | 1002 | 5 | 22 | 1132 | 8 | 1167 |
| 62 | 548 | 236 | 784 | 5 | 1607 | 154 | 46 | 1812 |
| 63 | 143 | 124 | 267 | 103 | 1954 | 1224 | 13 | 3294 |
| 64 | 577 | 435 | 1012 | 33 | 545 | 79 | 380 | 1037 |
| 65 | 260 | 195 | 455 | 11 | 53 | 21 | 953 | 1038 |
| 66 | 597 | 493 | 1090 | 24 | 201 | 540 | 146 | 911 |
| 67 | 3136 | 1128 | 4264 | 35 | 55 | 419 | 16 | 525 |
| 68 | 2953 | 369 | 3322 | 11 | 12 | 233 | 71 | 327 |
| 69 | 536 | 2023 | 2559 | 12 | 48 | 470 | 71 | 601 |
| 1970 | 583 | 2652 | 3235 | 0 | 32 | 150 | 73 | 255 |
| 71 | 75783 | 1154 | 76937 | 0 | 13115 | 187 | 2153 | 15455 |
| 72 | 72 | 26 | 98 | 30 | 128 | 2743 | 0 | 2901 |
| 73 | 60 | 60 | 120 | 0 | 44 | 190 | 0 | 234 |
| 74 | 649 | 29906 | 30555 | 0 | 1761 | 1911 | 17274 | 20946 |
| Total | 86736 | 44334 | 131070 | 289 | 19995 | 9472 | 22135 | 51891 |
| An Ave | 5782 | 2956 | 8738 | 19 | 1333 | 631 | 1476 | 3454 |

The average annual area burned by lightning fires per million acres protected in Region Three is more than 1100 acres. The annual amount of burned area per million acres varies from a high of 3401 acres in the Coronado National Forest to a low of only 13 acres on the Carson (Table II-21). In addition to the Coronado, four other national forests (Apache-Sitgreaves, Gila, Lincoln and Tonto) recorded annual average burns of more than 1000 acres per million.

Nearly sixty percent of the area burned by lightning fires in Region Three results from fires starting in June. During the 1960-1974 period the distribution of area burned by month of fire start was as follows (Table II-22):

| | | |
|---|---|---|
| April | 0.8 | percent |
| May | 17.7 | " |
| June | 59.2 | " |
| July | 18.1 | " |
| August | 2.5 | " |
| September | 1.4 | " |
| October | 0.2 | " |
| Other Months | 0.1 | " |

Table II-21. Average Annual Area Burned by Lightning Fires by National Forests and Zones in Region Three, 1960-1974.

| Forest and Zone | Average Annual Area Burned | Average Annual Area Burned Per Million Acres Protected | Area Burned Ranking | |
|---|---|---|---|---|
| | | | Forests | Zones |
| Kaibab | 1236 | 772 | 7 | |
| Coconino | 235 | 117 | 9 | |
| Prescott | 133 | 94 | 10 | |
| N. W. Zone | 1605 | 320 | | 4 |
| Coronado | 6312 | 3401 | 1 | |
| Tonto | 4179 | 1407 | 3 | |
| S.W. Zone | 10492 | 2174 | | 1 |
| Apache-Sitgreaves | 5782 | 2093 | 2 | |
| Gila | 2956 | 1057 | 5 | |
| Central Zone | 8738 | 1571 | | 2 |
| Carson | 19 | 13 | 11 | |
| Santa Fe | 1333 | 775 | 6 | |
| Cibola | 631 | 299 | 8 | |
| Lincoln | 1476 | 1161 | 4 | |
| Eastern Zone | 3459 | 525 | | 3 |
| Total Region Three | 24294 | 1104 | | |

Table II-22. Acres Burned by Lightning Fires in Region Three and in Each Zone, 1960-1974.

| | Northwestern Zone | Southwestern Zone | Central Zone | Eastern Zone | Total R-3 |
|---|---|---|---|---|---|
| April | 46 | 1089 | 1316 | 323 | 2774 |
| May | 10098 | 39842 | 7390 | 7031 | 64361 |
| June | 2403 | 66785 | 109209 | 37482 | 215879 |
| July | 10748 | 41261 | 7562 | 6303 | 65874 |
| August | 543 | 5589 | 2564 | 352 | 9048 |
| Sept. | 200 | 2086 | 2577 | 367 | 5230 |
| October | 29 | 156 | 452 | 19 | 656 |
| Other Months | 11 | 525 | 0 | 14 | 55 |
| Total | 24078 | 157374 | 131070 | 51891 | 364413 |

Fires starting in June cause the greatest area burned in the Southwestern, Central and Eastern Zones. In these three zones the percent of the area burned by lightning fires starting in June is as follows:

| | |
|---|---|
| Southwestern Zone | 42.44 percent |
| Central Zone | 83.32 " |
| Eastern Zone | 72.22 " |

In the Northwestern Zone only 9.98 percent of the burn results from June fires. The leading months for area burned in the Northwestern Zone are July with 44.64 percent and May with 41.94 percent. The area burned by months and years in all zones is shown in Tables II-23 through II-26.

Table II-23. Area Burned by Lightning Fires by Months, Northwestern Zone, 1960-1974.

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other Months | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 1 | 8676 | 199 | 752 | 6 | 0 | 0 | 3 | 9637 |
| 61 | 0 | 271 | 90 | 230 | 16 | 2 | 2 | 0 | 611 |
| 62 | 2 | 0 | 3 | 8720 | 59 | 32 | 1 | 0 | 8817 |
| 63 | 0 | 17 | 4 | 9 | 12 | 8 | 0 | 0 | 50 |
| 64 | 9 | 0 | 400 | 341 | 16 | 3 | 3 | 0 | 772 |
| 65 | 0 | 0 | 19 | 22 | 51 | 1 | 0 | 0 | 95 |
| 66 | 29 | 29 | 579 | 70 | 29 | 22 | 13 | 8 | 779 |
| 67 | 0 | 876 | 1012 | 56 | 0 | 10 | 0 | 0 | 1954 |
| 68 | 1 | 25 | 1 | 201 | 22 | 7 | 5 | 0 | 262 |
| 69 | 4 | 137 | 10 | 27 | 37 | 20 | 5 | 0 | 240 |
| 70 | 0 | 65 | 0 | 12 | 0 | 0 | 0 | 0 | 77 |
| 71 | 0 | 0 | 0 | 178 | 95 | 0 | 0 | 0 | 273 |
| 72 | 0 | 0 | 20 | 46 | 0 | 50 | 0 | 0 | 116 |
| 73 | 0 | 0 | 16 | 20 | 0 | 0 | 0 | 0 | 36 |
| 74 | 0 | 0 | 50 | 64 | 200 | 45 | 0 | 0 | 359 |
| Total | 46 | 10098 | 2403 | 10748 | 543 | 299 | 29 | 11 | 24078 |
| Percent | 0.19 | 41.94 | 9.98 | 44.64 | 2.25 | 0.83 | 0.12 | 0.05 | |

Table II-24. Area Burned by Lightning Fires by Months, Southwestern Zone, 1960-1974.

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other Months | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 0 | 13925 | 1001 | 167 | 2 | 0 | 0 | 0 | 15095 |
| 61 | 0 | 12590 | 908 | 143 | 0 | 0 | 0 | 0 | 13641 |
| 62 | 282 | 0 | 1410 | 197 | 231 | 310 | 5 | 0 | 2435 |
| 63 | 0 | 9 | 0 | 189 | 81 | 1 | 0 | 0 | 317 |
| 64 | 4 | 23 | 5860 | 774 | 19 | 6 | 5 | 0 | 669 |
| 65 | 742 | 4 | 454 | 14137 | 101 | 11 | 0 | 90 | 15539 |
| 66 | 13 | 12734 | 10866 | 981 | 128 | 20 | 0 | 3 | 24745 |
| 67 | 0 | 285 | 20 | 277 | 13 | 4 | 0 | 432 | 1031 |
| 68 | 48 | 5 | 23567 | 283 | 30 | 859 | 133 | 0 | 24925 |
| 69 | 0 | 180 | 663 | 3979 | 2817 | 233 | 0 | 0 | 7872 |
| 70 | 0 | 65 | 1677 | 16010 | 457 | 0 | 0 | 0 | 18209 |
| 71 | 0 | 0 | 1937 | 1999 | 0 | 60 | 0 | 0 | 3996 |
| 72 | 0 | 0 | 75 | 609 | 0 | 0 | 0 | 0 | 684 |
| 73 | 0 | 26 | 82 | 410 | 1137 | 65 | 0 | 0 | 1720 |
| 74 | 0 | 0 | 18265 | 1106 | 573 | 517 | 13 | 0 | 20474 |
| Total | 1089 | 39842 | 66785 | 41261 | 5589 | 2086 | 156 | 525 | 157374 |
| Percent | | | | | | | | | |

Table II-25. Area Burned by Lightning Fires by Months. Central Zone, 1960-1974.

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 3 | 157 | 115 | 5062 | 33 | 0 | 0 | 0 | 5370 |
| 61 | 31 | 660 | 153 | 101 | 11 | 46 | 0 | 0 | 1002 |
| 62 | 1 | 0 | 433 | 63 | 137 | 87 | 63 | 0 | 784 |
| 63 | 50 | 2 | 32 | 104 | 29 | 46 | 4 | | 267 |
| 64 | 0 | 216 | 165 | 169 | 181 | 0 | 281 | | 1012 |
| 65 | 4 | 30 | 31 | 258 | 88 | 14 | 30 | | 455 |
| 66 | 279 | 116 | 563 | 109 | 88 | 10 | 5 | 0 | 1090 |
| 67 | 0 | 3341 | 43 | 874 | 6 | 0 | 0 | | 4264 |
| 68 | 0 | 22 | 2894 | 58 | 5 | 274 | 69 | | 3322 |
| 69 | 40 | 1749 | 90 | 181 | 481 | 18 | 0 | | 2559 |
| 70 | 0 | 332 | 355 | 0 | 1111 | 1437 | 0 | | 3235 |
| 71 | 908 | 0 | 75659 | 107 | 28 | 235 | 0 | 0 | 76937 |
| 72 | 0 | 0 | 0 | 72 | 26 | 0 | 0 | 0 | 98 |
| 73 | 0 | 0 | 35 | 0 | 85 | 0 | 0 | | 120 |
| 74 | 0 | 765 | 28641 | 404 | 335 | 410 | 0 | | 30555 |
| Total | 1316 | 7390 | 109209 | 7562 | 2564 | 2577 | 452 | | 131070 |
| Percent | | | | | | | | | |

Table II-26. Area Burned by Lightning Fires by Months, Eastern Zone, 1960-1974

| Year | April | May | June | July | Aug. | Sept. | Oct. | Other Months | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 2 | 1349 | 11 | 6 | 11 | 7 | 0 | 0 | 1388 |
| 61 | 2 | 33 | 1114 | 7 | 0 | 0 | | 11 | 1167 |
| 62 | 27 | 11 | 1609 | 12 | 148 | 5 | 0 | | 1812 |
| 63 | 270 | 41 | 1674 | 1233 | 14 | 62 | 0 | | 3294 |
| 64 | 2 | 256 | 74 | 701 | 3 | 1 | 0 | 0 | 1037 |
| 65 | 0 | 991 | 20 | 14 | 8 | 2 | 3 | | 1038 |
| 66 | 9 | 354 | 385 | 138 | 19 | 3 | 3 | 0 | 911 |
| 67 | 1 | 52 | 70 | 387 | 10 | 4 | | 1 | 525 |
| 68 | | 4 | 202 | 83 | 7 | 18 | 13 | | 327 |
| 69 | | 62 | 71 | 442 | 22 | 4 | | | 601 |
| 70 | | 12 | 118 | 73 | 0 | 52 | | | 255 |
| 71 | 0 | 1575 | 13664 | 136 | 0 | 80 | | 0 | 15455 |
| 72 | | 70 | 63 | 2690 | 78 | 0 | 0 | | 2901 |
| 73 | 10 | 0 | 16 | 164 | 32 | 12 | 0 | | 234 |
| 74 | 0 | 2221 | 18391 | 217 | 0 | 117 | | 0 | 20946 |
| Total | 323 | 7031 | 37482 | 6303 | 352 | 367 | 19 | 19 | 51891 |
| Percent | 0.62 | 13.55 | 72.22 | 12.14 | 0.68 | 0.72 | 0.04 | 0.03 | |

## II-3. Summary of Fire Load

The foregoing analyses show the characteristics of the lightning fire load in Region Three National Forests. Results of these studies dramatically illustrate that lightning fires are important phenomena to be considered in the development of policies and programs for management of national forest resources. Fire management, especially in relation to overall natural resources management, is entering a dynamic era of new policies. These include provision for "prescription fire using either planned or unplanned ignitions to protect, maintain and enhance production of National Forest resources" (U.S. Forest Service, 1978). The knowledge now available on the lightning fire load provides an increased basis for regional development and implementation of these national policies. Other phases of this report on lightning fire environment, wilderness and critical fire situations include additional information for application in future fire management programs.

In evaluations of the total fire load it is necessary to consider both lightning and man-caused fires. A detailed study of the man-caused fire load was beyond the scope of this research. However a summary of the combined lightning and man-caused fire load was prepared (Table II-27).

Summary of the total fire load, 1960-1974, showed:

(1) A total of 35,081 lightning and man-caused fires in 15 years.
(2) 81 percent lightning caused fires.
(3) More than 3000 lightning and man-caused fires in three separate years (1961, 1972, 1974).
(4) A major increase in man-caused fires 1970 thru 1974.
(5) Peak single year lightning occurrence more than three times greater than peak man-caused fire year.
(6) A total of 372 class D or larger lightning and man-caused fires.
(7) 53 percent of class D or larger fires are lightning caused.
(8) In 10 of 15 years most class D or larger fires are lightning-caused.
(9) A total of 562,428 acres burned by lightning and man-caused fires.
(10) 65 percent of area burned by lightning fires.
(11) In 10 of 15 years largest area burned is by lightning fires.
(12) More than 100,000 acres burned by lightning and man-caused fires in two separate years (1971, 1974).

Table II-27. Summary of Fireload by Years for Lightning and Man-Caused Fires in Region Three, 1960-1974

| Year | Lightning Fires | | | Man-Caused Fires | | |
|---|---|---|---|---|---|---|
| | No. of Fires | No. of Class D or Larger Fires | Acres Burned | No. of Fires | No. of Class D or Larger Fires | Acres Burned |
| 1960 | 2546 | 17 | 31490 | 362 | 5 | 3839 |
| 61 | 2841 | 16 | 16421 | 267 | 5 | 4229 |
| 62 | 2210 | 8 | 13848 | 356 | 5 | 2701 |
| 63 | 1432 | 4 | 3928 | 339 | 13 | 4853 |
| 64 | 1661 | 11 | 9512 | 323 | 9 | 4475 |
| 65 | 1448 | 11 | 17127 | 340 | 7 | 7336 |
| 66 | 1490 | 11 | 27525 | 338 | 9 | 6045 |
| 67 | 1184 | 8 | 7774 | 347 | 20 | 32019 |
| 68 | 1246 | 13 | 28836 | 360 | 14 | 10036 |
| 69 | 1305 | 23 | 11272 | 365 | 17 | 15254 |
| 70 | 2200 | 15 | 21776 | 495 | 14 | 6659 |
| 71 | 2351 | 20 | 96661 | 563 | 21 | 18593 |
| 72 | 2462 | 3 | 3799 | 715 | 6 | 32616 |
| 73 | 1647 | 5 | 2110 | 775 | 8 | 17289 |
| 74 | 2342 | 32 | 72334 | 771 | 22 | 32071 |
| Total | 28365 | 197 | 364413 | 6716 | 175 | 198015 |

## III. LIGHTNING FIRE ENVIRONMENT

In the Southwest many features of the climate, local weather, topography and vegetative cover combine to provide a unique environment for lightning fires. At first glance it might be postulated that the arid Southwest has neither the frequency of atmospheric moisture situations for generation of substantial numbers of thunderstorms or the expanses of flammable wildland fuels to create a severe lightning fire environment. The long history of wildland fires shows that the overall natural environment of the Southwest operates in a fashion that produces a massive amount of lightning and fuel complexes conducive to fire ignition and spread.

This research of lightning fire environment concentrates on selected factors of lightning storm meteorology, climatology, topography, vegetative cover and fuel types. The main thrust of the studies is to determine the relationship of these environmental factors to the ignition and spread of lightning fires. The main data base is provided by climatological summaries for Arizona and New Mexico and individual fire reports showing the dates, location, size, topography, cover types and fuels for some 28,000 lightning fires.

## III-1. Fire Climate

In the Southwest there are two distinctly different fire seasons. During the principal months for lightning fire occurrence there is a spring dry season from April through June and a summer wet season (relatively speaking) from July through September. As shown in Table III-1 these dry and wet seasons occur in each national forest zone of the region. During both the dry and wet seasons the Eastern Zone has the largest amount of precipitation. The Southwest Zone has the least precipitation during both seasons.

The largest number of thunderstorm days occur during the wet fire season months. Table III-2 shows the average number of thunderstorm days, relative humidity and precipitation at selected cities in Arizona and New Mexico. Unfortunately similar long term climatic data are not available for higher elevations more representative of the national forest sites for most lightning fires. The fire records show a much larger number of thunderstorm days than indicated by the climatic data for the lower elevations. However, the general differences between the spring and summer periods shown in Table III-3 hold true throughout the region although the figures may be different. During the dry season the humidity is very low, precipitation is light and relatively few thunderstorm days are recorded. During the wet season all of these factors are increased. During July and August the average number of thunderstorm days is 7 to 14 times greater than the average for the spring months.

Synoptic weather patterns indicate lightning storm characteristics. During the dry spring season a high pressure system to the north of the region and moisture in a shallow layer aloft may produce dry thunderstorms. Moisture flow may be either from the southwest or southeast in this shallow layer. Normally as summer weather develops the Bermuda High moves westward in the Gulf of Mexico and produces a deep layer of moisture flow over the region. The resulting thunderstorms have large amounts of lightning and rainfall reaching the ground (Schroeder and Buck, 1970).

Lightning fires are most severe during the dry spring season. The combination of small amounts of precipitation and enough dry lightning storms to ignite significant numbers of fires results in a severe and sometimes critical fire situation (Table III-3). In each national forest zone of the region the spring season produces the largest area burned and average size per fire.

The largest number of fires and area burned during the spring season occurs in the Central Zone. As shown in Table III-3 the Central Zone averages 301 lightning fires and 7861 acres burned annually during the April-June period.

It is notable that the number of spring lightning fires is almost as great as the summer occurrence in Central Zone. Only the Northwest Zone has a larger number of lightning fires during the summer months.

The Southwest Zone has a persistently severe lightning fire problem during both the spring and summer periods. This zone has less precipitation than any other zone in the region during both the spring and summer. While average annual occurrence is only 96 lightning fires during the spring months the average size of these fires is 74.8 acres. During the summer months the average size per lightning fire of 14.24 acres is also the largest of any zone. For the combined dry and wet seasons the Southwest Zone has the greatest area burned by lightning fires (Table III-3).

Table III-1. Approximate Average Annual Inches of Precipitation at Lower Elevations in Each Zone of Region Three, April - September. (1)

| Month | Northwest | Southwest | Central | Eastern | |
|---|---|---|---|---|---|
| | Coconino, Kaibab, Prescott | Tonto Coronado | Apache-Sitgreaves Gila | Carson Santa Fe | Cibola Lincoln |
| April | .65 | .39 | .54 | 1.12 | .79 |
| May | .23 | .14 | .50 | 1.65 | 1.10 |
| June | .17 | .14 | .75 | 1.24 | 1.25 |
| July | .97 | 1.06 | 2.27 | 2.34 | 2.94 |
| Aug | 1.63 | 1.56 | 2.71 | 2.76 | 2.95 |
| Sept. | 1.10 | .83 | 1.61 | 1.64 | 1.86 |

(1) Estimates from data in Climates of the States (Arizona and New Mexico) Vol. II, NOAA, U.S. Dept. of Commerce, 1974.

Table III-2. Average Thunderstorm Days, Relative Humidity and Precipitation During Fire Season Months at Selected Stations in the Southwest. (1)

| Station | Weather Factor (2) | Month April | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|
| Flagstaff | T.S. | 2 | 2 | 4 | 16 | 16 | 6 |
| | R.H. | 34% | 24% | 19% | 37% | 42% | 41% |
| | Precip. | 1.18 | .51 | .69 | 2.28 | 2.84 | 1.58 |
| Phoenix | T.S. | 1 | 1 | 1 | 6 | 7 | 3 |
| | R.H. | 18% | 13% | 13% | 20% | 26% | 25% |
| | Precip. | .32 | .13 | .09 | .77 | 1.12 | .73 |
| Tucson | T.S. | 1 | 1 | 2 | 14 | 14 | 5 |
| | R.H. | 11% | 12% | 13% | 28% | 34% | 26% |
| | Precip. | .27 | .13 | .29 | 2.06 | 2.88 | 1.00 |
| Winslow | T.S. | 2 | 2 | 3 | 11 | 11 | 5 |
| | R.H. | 19% | 14% | 12% | 26% | 32% | 31% |
| | Precip. | .45 | .32 | .26 | 1.02 | 1.43 | .91 |
| Albuquerque | T.S. | 2 | 4 | 5 | 12 | 12 | 5 |
| | R.H. | 18% | 16% | 17% | 28% | 31% | 31% |
| | Precip. | .47 | .75 | .57 | 1.20 | 1.33 | .95 |

(1) Data from Climates of the States (Arizona and New Mexico) Vol II, NOAA, U.S. Dept of Commerce, 1974.

(2) T.S. = No. of thunderstorm days
R.H. = Relative Humidity
Precip. = Inches of precipitation

Table III-3. Comparison Between Precipitation and Lightning Fire Occurrence, Acres Burned and Average Size Per Fire During Dry and Wet Fire Season Months in Each Zone. (1)

| | Northwest Coconino, Kaibab, Prescott | Southwest Tonto, Coronado | Central Apache-Sitgreaves Gila | Eastern Carson, Cibola Santa Fe, Lincolr |
|---|---|---|---|---|
| Dry Months (April-June) | | | | |
| Average inches of Precipitation | 1.05 | .67 | 1.79 | 3.57 |
| Average Annual No of Lightning Fires | 138 | 96 | 301 | 151 |
| Average Annual Acres Burned | 836 | 7181 | 7861 | 2984 |
| Average Size Per Fire (Acres) | 6.06 | 74.80 | 26.12 | 19.79 |
| Wet Months (July-Sept) | | | | |
| Average Inches of Precipitation | 3.70 | 3.45 | 6.59 | 7.27 |
| Average Annual No. of Lightning Fires | 412 | 229 | 387 | 162 |
| Average Annual Acres Burned | 766 | 3262 | 847 | 468 |
| Average Size Per Fire | 0.17 | 14.24 | 2.19 | 2.84 |

(1) Precipitation averages calculated from data in Climate of the States (Arizona and New Mexico) Vol. II, NOAA, U. S. Dept. of Commerce, 1974.

## III-2. Topography

### Elevation Zone

In Region Three more than three fourths of the lightning fires occur at elevations above 6500 feet. During the period 1960-1974 a total of 22,209 lightning fires occurred in the elevation zones above 6500 feet (Table III-4). The peak occurrence zone is 6501 to 7500 feet with 40.15 percent of the lightning fires. This pattern of fire occurrence in the higher elevations is found in all national forest zones of the region except in the Southwest Zone where the largest number of fires are in the elevations of 5501 to 6500 feet.

Peak occurrence of high elevation fires is in the Eastern and Central Zones. In the Eastern Zone 95.66 percent of the lightning fires occur at elevations above 6500 feet with the greatest number of fires being at elevations of 7501 to 8500 feet. In the Central Zone 89.98 percent of the fires are above 6500 feet. In total number of fires the greatest concentration in Region Three is at elevations of 6501 to 8500 feet in the Central Zone. The Central Zone also leads in number of fires above 8500 feet. The second largest concentration of high elevation fires is from 6501 to 8500 feet and is in the Northwest Zone (Table III-4). These data reflect the importance of the high mountain ranges in lightning fire occurrence.

The greatest number of Class C or larger lightning fires originate at elevations of 4501 to 7500 feet. During the 1960-1974 period 486 fires of this size class originated in the elevation range of 4501 to 7500 feet. This was 59.05 percent of the total number of Class C or larger fires (Table III-5).

The greatest number of Class G lightning fires originated at elevations of 6501 to 8500 feet. In the 15 year study period 10 fires of more than 5000 acres in size occurred in these high elevation zones (Table III-5). This was 66 percent of the Class G fires. This concentration of very large fires at these high elevations probably reflects combined effects of fuel loadings, terrain difficulties and accessibility for fire control forces. A summary of all large fires is contained in Part IV of this report.

Table III-4. Lightning Fire Occurrence By Elevation in Each National Forest Zone of Region Three, (1960-1974.

| Zone | No. of Fires and % | Elevation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Below 2501 | 2501-3500' | 3501-4500' | 4501-5500' | 5501-6500' | 6501-7500' | 7501-8500' | Over 8500' |
| Northwestern | | | | | | | | | |
| | No. | 1 | 20 | 135 | 330 | 1433 | 4169 | 1036 | 149 |
| | % | .01 | .24 | 1.61 | 3.94 | 18.42 | 61.65 | 12.36 | 1.78 |
| Southwestern | | | | | | | | | |
| | No. | 58 | 138 | 351 | 855 | 1491 | 1112 | 682 | 209 |
| | % | 1.18 | 2.82 | 7.17 | 17.46 | 30.45 | 22.71 | 13.93 | 4.27 |
| Central | No. | 8 | 0 | 18 | 81 | 932 | 3973 | 3946 | 1413 |
| | % | .08 | - | .17 | .78 | 8.99 | 38.31 | 38.05 | 13.62 |
| Eastern | | | | | | | | | |
| | No. | 19 | 1 | 4 | 24 | 157 | 1140 | 2355 | 1025 |
| | % | .40 | .02 | .08 | .51 | 3.32 | 24.13 | 49.84 | 21.69 |
| Region Three | | | | | | | | | |
| | No. | 86 | 159 | 508 | 1290 | 4124 | 11394 | 8019 | 2796 |
| | % | .30 | .56 | 1.79 | 4.55 | 14.53 | 40.15 | 28.26 | 9.85 |

Table III-5. Occurrence of Class C or Larger Lightning Fires By Size Class and Elevation Zone in Region Three, 1960-1974.

| Elevation Zone | Size Class C | D | E | F | G | Total | % of Class C or Larger Fires |
|---|---|---|---|---|---|---|---|
| Below 2501 | 9 | 0 | 0 | 0 | 0 | 9 | 1.09 |
| 2501-3500 | 25 | 4 | 3 | 0 | 2 | 34 | 4.13 |
| 3501-4500 | 65 | 21 | 9 | 7 | 1 | 111 | 13.49 |
| 4501-5500 | 130 | 24 | 21 | 7 | 0 | 182 | 22.11 |
| 5501-6500 | 93 | 20 | 13 | 11 | 2 | 139 | 16.89 |
| 6501-7500 | 138 | 10 | 8 | 3 | 6 | 165 | 20.05 |
| 7500-8500 | 104 | 13 | 5 | 3 | 4 | 129 | 15.68 |
| Above 8500 | 48 | 4 | 1 | 1 | 0 | 54 | 6.56 |
| Total | 623 | 96 | 60 | 29 | 15 | 823 | |

## Aspect

Lightning fires are randomly distributed by aspect. In studies of 28,376 lightning fires only slight differences were found in occurrence on various aspects (Table III-6). Surprisingly nearly 27 percent of the fires occurred on north and northwest aspects as compared to 20 to 31 percent on other aspects. Earlier studies of lightning fires in the Northern Rocky Mountains have shown the greatest occurrence of fires on south and southwest aspects (Barrows, 1951). In Region Three it is probable that tree distribution on northerly aspects may be a factor contributing to somewhat greater occurrence of lightning fires.

Class C or larger lightning fires are also randomly distributed by aspect. The distribution of fires reaching Class C or larger size varied from 2.31 percent on north and northeast aspects to 3.78 percent on south and southwest aspects (Table III-6). The drier climate on the southerly aspects would be expected to influence development of larger fires. A total of 405 Class C or larger fires occurred on east-southeast and south-southwest aspects during the period 1960-1974).

Nearly one-half of the lightning fires burning more than 5000 acres originate on north and northeast aspects. A total of seven of the fifteen Class G fires ignited on these aspects. The distribution was as follows:

| Aspect | No. of Class G Fires | % of Class C Fires |
|---|---|---|
| North and northeast | 7 | 46.67 |
| East and southeast | 3 | 20.00 |
| South and southwest | 2 | 13.33 |
| West and northwest | 1 | 6.67 |
| Ridgetop | 2 | 13.33 |
| Flat | 0 | 0. |

Table III-6. Distribution of Lightning Fires and Class C or Larger Fires by Aspect in Region Three, 1960-1974.

| Aspect | Total Number of Fires | Number of Class C or Larger Fires | Percent Class C or Larger Fires |
|---|---|---|---|
| North and Northeast | 7655 (26.98%) | 177 | 2.31 |
| East and Southeast | 5786 (20.39%) | 181 | 3.13 |
| South and Southwest | 5924 (20.88%) | 224 | 3.78 |
| West and Northwest | 6030 (21.25%) | 176 | 2.92 |
| Ridgetop | 954 (2.36%) | 35 | 3.67 |
| Flat | 2027 (7.18%) | 28 | 1.38 |
| Total | 28376 | 821 | |

## Slope Steepness

More than fifty percent of the lightning fires occur on gentle slopes. During the 15 year study period 15,525 lightning fires, 54.71 percent of the total ignitions occurred on slopes of less than 20 percent (Table II-7). The distribution of these fires by national forest zones was as follows:

| | Slope Steepness | | |
|---|---|---|---|
| Zone | 0-19% | 20-39% | 40% or more |
| Northwest | 6157 | 1296 | 931 |
| Southwest | 1604 | 1164 | 2129 |
| Central | 5303 | 2373 | 2695 |
| Eastern | 2461 | 1174 | 1090 |

The Southwest national forest zone leads the region in percent of fires occurring on steep slopes. More than 43 percent of the lightning fires in the Southwest Zone occurred on slopes of 40 percent or more. In contrast only 11 percent of the fires in the Northwest Zone occurred on these steep slopes. This reflects the vast expanse of gentle topography on the Coconino Plateau where large numbers of lightning fires occur. The Eastern and Central Zones had 23 and 26 percent respectively of their lightning fires on slopes of 40 percent or more.

The percent of Class C or larger fires increased with slope steepness. Only 1.60 percent of the lightning fires originating on slopes of 0-19 percent spread to Class C or larger size. On slopes of 20-39 percent 2.88 percent of the fires spread to this size. The peak occurrence of Class C or larger fires was on slopes of 40 percent or more. On these steep slopes 400 fires or 5.84 percent spread to sizes of 10 acres or more (Table III-7).

Steep slopes are breeders of very large fires. More than half (53.33%) of the Class G lightning fires originated on slopes of 40 percent or more (Table III-7). These fires burning 5000 or more acres were all in the Southwest and Central Zones distributed on national forests as follows:

| | |
|---|---|
| Coronado | 2 fires |
| Tonto | 2 " |
| Apache-Sitgreaves | 3 " |
| Gila | 1 " |

Table III-7 Lightning Fire Occurrence and Size Class by Slope Steepness in Region Three, 1960-1974.

| | Slope Steepness | | |
|---|---|---|---|
| | 0-19% | 20-39% | 40% or more |
| Number of Fires | 15,525 | 6.007 | 6,845 |
| Percent of Fires | 54.71 | 21.17 | 24.12 |
| Number of Class C or Larger Fires | 249 | 173 | 400 |
| Percent of Fires Reaching Class C or Larger Size | 1.60 | 2.88 | 5.84 |
| Number of Class G Fires | 5 | 2 | 8 |
| Percent of Class G Fires | 33.33 | 13.33 | 53.33 |

## III-3. Cover Type

In Region Three the individual fire report data permitted analyses of fires in seven vegetative cover types -- grass, brush, spruce, mixed conifer, ponderosa pine, aspen and woodland. The data reflects the dominate cover type at the fire site. Unfortunately standardized measure of the acres in each of these cover types was not available. As a result the fire data could not be analyzed on a unit area basis.

More than three-fourths of the lightning fires occur in forested areas. During the period 1969-1974 a total of 21,572 lightning fires occurred in the spruce, mixed conifer, ponderosa pine, aspen and woodland cover types (Table III-8). This was 76 percent of the total number of lightning fires. Fires in grass and brush fuels accounted for 24 percent of the total. In addition a small number of fires (24 in logging slash and 9 in clear cut areas) were not identified by forest cover type.

More than sixty percent of the lightning fires occur in ponderosa pine. A total of 17,067 fires, 68.38 percent, occurred in the ponderosa pine type. This is a very high fire occurrence rate and is estimated to be greatly in excess of other types on a unit area basis. While ponderosa pine is the major forest cover type of the region an even greater area consists of grass, brush and woodland types. Even in the Southwest Zone noted for expanses of grass, brush and woodland types the largest number of lightning fires occur in ponderosa pine. In each zone of Region Three the largest number of lightning fires is in ponderosa pine. The peak fire occurrence is in the vast ponderosa pine forests of the Northwest and Central Zones (Table III-8).

Large numbers of lightning fires occur in grass. As shown in Table III-8 5516 fires or 19.52 percent of the total occurred in grass. In all zones except the Eastern grass was the second most common cover type for lightning fire occurrence.

Lightning fire growth rates are very high in brush and grass cover types. During the 15 year study period 9.69 percent of the fires in brush and 7.12 percent in grass reached Class C or larger size (Table III-8). These fire growth rates are double or more those found in any other cover type. Fires in the woodland cover type rank third in percent spreading to Class C or larger size.

It is interesting to note that only 1.21 percent of the fires in ponderosa pine reached Class C or larger size. Only aspen and spruce had a smaller percentage of such fires. Not a single fire in aspen spread to Class C size and only one occurred in spruce.

The greatest number of big fires occur in grass. During the study period 113 (57.65 percent) of the fires burning more than 100 acres were in grass (Table III-9). The greatest concentration of these large grass fires was in the Southwest Zone. In that zone 71 Class D or larger grass fires accounted for 62.83 percent of the large grass fires in the region.

All of the Class G fires were in grass, brush or ponderosa pine. As shown in Table III-9 six fires burning more than 5000 acres occurred in both the grass and ponderosa pine types and 3 in the brush types. Each national forest zone had one or more Class G lightning fires in ponderosa pine. All of the Class G fires in brush occurred in the Southwest Zone.

Table III-8. Distribution of Lightning Fires By Cover Type In Each National Forest Zone of Region Three, 1960-1974.

| | Grass | Brush | Spruce | Mixed Conifer | Ponderosa Pine | Aspen | Woodland |
|---|---|---|---|---|---|---|---|
| Northwestern Zone | 1422 | 165 | 5 | 419 | 5612 | 4 | 742 |
| Southwestern Zone | 1295 | 677 | 3 | 288 | 2350 | 2 | 276 |
| Central Zone | 1952 | 184 | 54 | 907 | 6721 | 30 | 503 |
| Eastern Zone | 847 | 151 | 58 | 914 | 2384 | 20 | 274 |
| Total Number of Fires | 5516 | 1177 | 120 | 2528 | 17,067 | 56 | 1801 |
| Percent of Fires in Region | 19.52 | 4.16 | .42 | 8.94 | 60.38 | .20 | 6.37 |
| Number of Class C or larger fires | 393 | 114 | 1 | 35 | 206 | 0 | 65 |
| Percent Class C or Larger Fires | 7.12 | .69 | .83 | 1.38 | 1.21 | 0 | 3.61 |

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Table III-9. Number of Class D or Larger Lightning Fires By Cover Type In Each National Forest Zone of Region Three, 1960-1974.

| Zone | | Grass | Brush | Spruce | Mixed Conifer | Ponderosa Pine | Aspen | Woodland |
|---|---|---|---|---|---|---|---|---|
| Northwest | D | 7 | 2 | 0 | 0 | 1 | | 0 |
| | E | 1 | 0 | 0 | 1 | 2 | | 0 |
| | F | 0 | 0 | 0 | 0 | 1 | | 0 |
| | G | 0 | 0 | 0 | 0 | 1 | | 0 |
| | Total | 8 | 2 | 0 | 1 | 5 | 0 | 0 |
| Southwest | D | 32 | 8 | 0 | 1 | 3 | | 6 |
| | E | 29 | 6 | 0 | 0 | 1 | | 3 |
| | F | 8 | 7 | 0 | 0 | 0 | | 3 |
| | G | 2 | 3 | 0 | 0 | 2 | | 0 |
| | Total | 71 | 24 | 0 | 1 | 6 | 0 | 12 |
| Central | D | 8 | 0 | 0 | 1 | 9 | | 0 |
| | E | 4 | 0 | 0 | 0 | 3 | | 0 |
| | F | 3 | 0 | 0 | 0 | 1 | | 1 |
| | G | 3 | 0 | 0 | 0 | 2 | | 0 |
| | Total | 18 | 0 | 0 | 1 | 15 | 0 | 1 |
| Eastern | D | 9 | 2 | 0 | 2 | 3 | | 0 |
| | E | 2 | 2 | 0 | 1 | 1 | | 0 |
| | F | 2 | 1 | 0 | 0 | 2 | | 0 |
| | G | 1 | 0 | 0 | 0 | 1 | | 0 |
| | Total | 14 | | 0 | 3 | 7 | 0 | 0 |
| Region Three | D | 58 | 12 | 0 | 4 | 16 | | 6 |
| | E | 36 | 8 | 0 | 2 | 7 | | 3 |
| | F | 13 | 8 | 0 | 0 | 4 | | 4 |
| | G | 6 | 3 | 0 | 0 | 6 | | 0 |
| | Total | 113 | 31 | 0 | 6 | 33 | 0 | 13 |

## III-4. Fuel Type

The fuel type classification system has been a good indicator of fuel flammability in Region Three. Under the system fuels were classified according to rate of fire spread and resistance to control efforts. For both categories fuels were given general ratings of Low, Medium, High and Extreme. As shown in Table III-10 an increasing percentage of fires reach Class C or larger size as the fuel rate of spread classification increases. In Region Three only 1.29 percent reach Class C or larger size in low rate-of-spread fuels as compared to 13.50 percent in the extreme classification.

More than three-fourths of the lightning fires ignite in medium and high rate-of-spread fuels. During the period 1960-1974 a total of 22,260 fires occurred in these fuel types (Table III-10). Moreover a greater number of fires occurred in extreme than in low rate-of-spread fuels. In the Southweatern Zone 23.66 percent of all lightning fires occurred in extreme rate-of-spread fuels.

Eighty two percent of the area burned is in high and extreme rate-of-spread fuels. This striking relationship is strongly influenced by large burns in the Southwestern and Central Zones in high and extreme fuels (Table III-11). In the Northwestern Zone the largest area burned was in medium fuels. Also in the Central Zone the second largest area burned was in medium fuels.

Average fire size increases with an increase in fuel rate-of-spread classification. In Region Three the average fire size increases steadily from 3.05 acres in low fuels to 48.45 acres in extreme fuels. This scale of fire size by fuel type is most striking in the Southwestern Zone. Some variations are noted in other Zones. In the Northwestern Zone the largest average fire size occurred in medium rate-of-spread fuels (Table III-11).

Nearly two-thirds of the lightning fires occur in medium resistance-to-control fuels. In every zone of Region Three the largest number of fires are in medium resistance-to-control fuels (Table III-12). However, it is also notable that a relatively large number of fires in the Southwestern and Central Zones were recorded in extreme resistance-to-control fuels.

The largest number and percentage of Class C or larger fires are in low resistance-to-control fuels. As shown in Table III-12 more than ten percent of the fires reached Class C or larger size in low fuels. A much smaller percent of large fires was recorded in the medium and high classes and only 5.52 percent in the extreme resistance-to-control class.

Table III-10. Distribution of Lightning Fires by Fuel Rate-of-Spread Type in Each National Forest Zone, 1976-1974.

| | Fuel Rate of Spread Class | | | | Total # of Fires in Each Zone |
|---|---|---|---|---|---|
| | Low | Medium | High | Extreme | |
| Northwestern Zone | 813 | 2293 | 4463 | 813 | 8382 |
| % Fires in each class | 9.7 | 27.36 | 53.25 | 9.7 | |
| Southwestern Zone | 304 | 2178 | 1252 | 1157 | 4891 |
| % Fires in each class | 6.22 | 44.53 | 25.6 | 23.66 | |
| Central Zone | 1110 | 5186 | 3153 | 914 | 10363 |
| % Fires in each class | 10.71 | 50.04 | 30.43 | 8.82 | |
| Eastern Zone | 718 | 2276 | 1459 | 249 | 4762 |
| % Fires in each class | 15.27 | 48.4 | 31.03 | 5.3 | |
| Total Number of Fires | 2945 | 11933 | 10327 | 3133 | 28338 |
| Percent of Fires in Region | 10.39 | 42.11 | 36.44 | 11.06 | |
| Number of Class C or Larger Fires | 38 | 186 | 176 | 423 | |
| Percent Class C or Larger Fires | 1.29 | 1.56 | 1.70 | 13.50 | |

Table III-11. Acres Burned and Average Fire Size by Fuel Rate-of-Spread Type in Each National Forest Zone, 1960-1974.

| Fuel Rate of Spread Type | | Zone | | | | Region Three |
|---|---|---|---|---|---|---|
| | | Northwest | Southwest | Central | Eastern | |
| Low | Acres Burned | 749 | 1233 | 4201 | 2796 | 8979 |
| | Average Size Per Fire | 0.92 | 4.07 | 3.78 | 3.90 | 3.05 |
| Medium | Acres Burned | 9511 | 17282 | 13856 | 15778 | 56427 |
| | Average Size Per Fire | 4.15 | 7.93 | 2.67 | 6.93 | 4.73 |
| High | Acres Burned | 2521 | 42411 | 90763 | 6440 | 142135 |
| | Average Size Per Fire | 0.56 | 33.87 | 28.79 | 4.41 | 13.76 |
| Extreme | Acres Burned | 2179 | 83547 | 32966 | 33114 | 151806 |
| | Average Size Per Fire | 2.68 | 72.21 | 36.07 | 132.99 | 48.45 |

Table III-12. Distribution of Lightning Fires by Resistance-to-Control Classification in Each National Forest Zone, 1960-1974.

| | Resistance to Control Class | | | | Total # of Fires |
|---|---|---|---|---|---|
| | Low | Medium | High | Extreme | |
| Northwestern Zone | 969 | 4598 | 2538 | 278 | 8383 |
| % Fires in each class | 11.56 | 54.85 | 30.28 | 3.32 | |
| Southwestern | 806 | 2736 | 937 | 412 | 4891 |
| % Fires in each class | 16.48 | 55.94 | 19.16 | 8.42 | |
| Central | 858 | 7532 | 1340 | 634 | 10364 |
| % Fires in each class | 8.28 | 72.67 | 12.93 | 6.12 | |
| Eastern | 456 | 3359 | 803 | 88 | 4706 |
| % Fires in each class | 9.69 | 71.38 | 17.06 | 1.87 | |
| Total Number of Fires | 3089 | 18225 | 5618 | 1412 | 28344 |
| Percent of Fires in Region | 10.90 | 64.30 | 19.82 | 4.98 | |
| Number of Class C or Larger Fires | 318 | 265 | 162 | 78 | |
| Percent Class C or Larger Fires | 10.29 | 1.45 | 2.88 | 5.52 | |

# IV LIGHTNING FIRE CONTROL

The control of lightning-caused forest fires involves many significant factors. These include: prompt detection in remote areas; identification of potentially dangerous and damaging fires; selection of fire attack methods; determination of needed strength for attack forces; and mobilization of resources to control large fires. All of these factors in the Southwest are compounded by topography, fuels, weather, travel distances and large numbers of lightning fires occurring in short periods of time.

In this study of lightning fire control the goal has been to perform analyses that will aid in fire management decision making. The studies are centered on analysis of fire detection, initial fire attack, reinforcement of attacks and suppression of large fires.

## IV-1. Fire Detection

One-half of the lightning fires in Region Three are detected within three hours. The elapsed detection time varies somewhat by size class of fire (Table IV-1). Class D or larger fires are detected faster than the Class A, B and C fires. During the 15 year study period 61.61 percent of the Class D or larger fires were detected within three hours and 51.51 percent within one hour. This indicates that these large fires often have highly visable burning characteristics shortly after ignition.

Long detection times for many lightning fires are common. During the 1960-1974 period a total of 2790 fires had elapsed detection times of more than 24 hours (Table IV-1). This is nearly ten percent of all lightning fires. It is significant to note that 20.51 percent of the Class C fires had elapsed detection times in excess of 24 hours. Moreover 39.90 percent of the Class C fires had detection times of more than 12 hours.

Little variation exists in elapsed detection time between national forest zones. The percent of fires detected within three hours varied from 46.07 percent in the Eastern Zone to 54.87 percent in the Southwest Zone (Table IV-2). The Central and Eastern Zones had the highest percentage of fires with detection times of more than 12 hours. The Southwestern Zone has a slightly better record than any other zone in all categories of elapsed detection time.

Forest Service lookouts and aircraft detect 72 percent of the lightning fires. As shown in Table IV-3 Forest Service lookouts and aircraft detected 55 and 17 percent respectively of the lightning fires. The third leading method of detection was other Forest Service personnel with 10 percent of the fires.

Forest Service ground based personnel, cooperators and permitees detect fires quickly. More than 50 percent of the fires detected by these personnel are detected within three hours. Forest Service patrolmen and lookouts lead all other categories in fast detection time (Tables IV-3 and IV-4). Patrolmen detected 57 percent of their fires within 3 hours and looks 55 percent in this elapsed time. Moreover patrolmen and lookouts detected 41 and 36 percent of their fires respecitvely within one hour.

Forest Service aircraft detect 59 percent of their fires within 12 hours. As shown in Table IV-4 aircraft also detected 38 percent of their fires within 3 hours. This is relatively fast detection time when it is recognized that many aircraft patrol flights are planned for operations during the best daylight hours for smoke visibility following lightning storms. Use of infrared scaners at night following lightning storms would probably speed up detection by aircraft.

Table IV-1. Summary of Elapsed Detection Time For Lightning Fires By Size Class in Region Three, 1960-1974.

| Elapsed Detection Time | | Class A and B Fires | Class C Fires | Class D or Larger Fires | All Fires |
|---|---|---|---|---|---|
| 1 Hr | No | 8825 | 256 | 102 | 9183 |
| | % | 32.03 | 41.03 | 51.51 | 32.36 |
| 2 Hrs | No | 3101 | 53 | 15 | 3169 |
| | % | 11.25 | 8.49 | 7.57 | 11.17 |
| 3 Hrs | No | 1821 | 28 | 5 | 1854 |
| | % | 6.61 | 4.49 | 2.53 | 6.53 |
| 4 Hrs | No | 1088 | 9 | 4 | 1101 |
| | % | 3.95 | 1.44 | 2.02 | 3.88 |
| 6 Hrs | No | 998 | 16 | 4 | 1018 |
| | % | 3.62 | 2.57 | 2.02 | 3.59 |
| 7-12 Hrs | No | 1968 | 13 | 5 | 1986 |
| | % | 7.14 | 2.08 | 2.53 | 7.00 |
| 13-24 Hrs | No | 7113 | 121 | 42 | 7276 |
| | % | 25.81 | 19.39 | 21.21 | 25.64 |
| over 24 Hrs | No | 2641 | 128 | 21 | 2790 |
| | % | 9.59 | 20.51 | 10.61 | 9.83 |
| Total | No | 27,555 | 624 | 198 | 28,377 |

Table IV-2. Distribution Of Lightning Fires By Elapsed Detection Time In Each National Forest Zone, 1960-1974.

| Elapsed Detection Time | Northwest Zone | Southwest Zone | Central Zone | Eastern Zone |
|---|---|---|---|---|
| 1 Hr | 3188 | 1903 | 2789 | 1303 |
| 2 Hrs | 884 | 485 | 1264 | 536 |
| 3 Hrs | 445 | 299 | 772 | 338 |
| 4 Hrs | 269 | 143 | 492 | 197 |
| 5 Hrs | 164 | 97 | 257 | 115 |
| 6 Hrs | 88 | 63 | 167 | 67 |
| 7-12 Hrs | 627 | 435 | 575 | 349 |
| 12-24 Hrs | 1891 | 1107 | 2959 | 1319 |
| 25-48 Hrs | 473 | 232 | 661 | 310 |
| Over 48 Hrs | 355 | 133 | 435 | 191 |
| Total | 8384 | 4897 | 10371 | 4725 |
| Summary | | | | |
| Within 3 Hrs | 53.88% | 54.87% | 46.52% | 46.07% |
| More Than 12 Hrs | 32.43% | 30.06% | 39.10% | 38.52% |
| More Than 48 Hrs | 4.23% | 2.72% | 4.19% | 4.04% |

Table IV-3. Elapsed Detection Time by Detection Method For Lightning Fires in Region Three, 1960-1974.

| | | 1 Hr | 2 Hrs | 3 Hrs | 4 Hrs | 5 Hrs | 6 Hrs | 7-12 Hrs | 13-24 Hrs | 25-48 Hrs | Over 48 Hrs | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F.S. Lookout | # | 5690 | 1860 | 1080 | 601 | 301 | 179 | 1057 | 3727 | 794 | 475 | 15,764 |
| | % | 36. | 12. | 7. | 4. | 2. | 1. | 7. | 24. | 5. | 3. | 55 |
| Other Lookout | # | 41 | 18 | 9 | 2 | 3 | 0 | 3 | 48 | 14 | 14 | 152 |
| | % | 27 | 12 | 6 | 1 | 2 | 0 | 2 | 32 | 9 | 9 | 1 |
| Patrolman | # | 367 | 86 | 55 | 27 | 16 | 8 | 53 | 220 | 47 | 26 | 905 |
| | % | 41 | 10 | 6 | 3 | 2 | 1 | 6 | 24 | 5 | 3 | 3 |
| Other F.S. Personnel | # | 803 | 300 | 161 | 113 | 63 | 42 | 169 | 804 | 250 | 213 | 2,918 |
| | % | 28 | 10 | 6 | 4 | 2 | 1 | 6 | 28 | 9 | 7 | 10 |
| Cooperator | # | 170 | 44 | 20 | 12 | 10 | 6 | 20 | 102 | 36 | 27 | 447 |
| | % | 38 | 10 | 4 | 3 | 2 | 1 | 4 | 23 | 8 | 6 | 2 |
| F.S. Permittee | # | 296 | 82 | 44 | 25 | 20 | 17 | 35 | 214 | 66 | 43 | 842 |
| | % | 35 | 10 | 5 | 3 | 2 | 2 | 4 | 25 | 8 | 5 | 3 |
| F.S. Aircraft | # | 1022 | 506 | 324 | 223 | 147 | 94 | 514 | 1534 | 264 | 138 | 4766 |
| | % | 21 | 11 | 7 | 5 | 3 | 2 | 11 | 32 | 6 | 3 | 17 |
| Other Aircraft | # | 84 | 48 | 25 | 13 | 11 | 7 | 33 | 171 | 59 | 51 | 502 |
| | % | 17 | 10 | 5 | 3 | 2 | 1 | 7 | 34 | 12 | 10 | 2 |
| Others | # | 710 | 225 | 136 | 85 | 62 | 32 | 102 | 456 | 146 | 127 | 2081 |
| | % | 34 | 11 | 7 | 4 | 3 | 2 | 5 | 22 | 7 | 6 | 7 |
| Total | # | 9183 | 3169 | 1854 | 1101 | 633 | 385 | 1986 | 7276 | 1676 | 1114 | 28,377 |

Table IV-4. Summary Of Elapsed Detection Time By Detection Method For Lightning Fires in Region Three, 1960-1974.

| Detection Method | Total Fires Detected | % Detected Within 3 Hrs | % Detected More than 12 Hrs | % Detected More than 48 Hrs |
|---|---|---|---|---|
| F.S. Lookout | 15,764 | 55 | 33 | 3 |
| Other Lookout | 152 | 45 | 50 | 9 |
| Patrolman | 905 | 57 | 32 | 3 |
| Other F.S. Personnel | 2,918 | 44 | 44 | 7 |
| Cooperator | 447 | 52 | 37 | 6 |
| F.S. Permitee | 842 | 50 | 38 | 5 |
| F.S. Aircraft | 4,766 | 38 | 41 | 3 |
| Other Aircraft | 502 | 32 | 56 | 10 |
| Others | 2,081 | 52 | 35 | 6 |
| Total | 28,377 | 50 | 36 | 4 |

## IV-2. Initial Attack

More than two-thirds of the lightning fires are initially attacked by ground forces using hand tools. During the period 1960-1974 the initial attack for 68.58 percent of the fires was by ground based fire fighters using hand tools. The second leading initial attack method was helitack forces (helicopter delivered fire fighters) accounting for 16.63 percent of the fires. Smoke jumpers made initial attack on 3.59 percent of the fires. Hand tool fire-fighters including both airborne and ground forces thus provided the initial attack for 88.80 percent of the lightning fires (Table IV-5).

Ground forces using power equipment made initial attack on less than nine percent of the lightning fires. These initial attack methods include 7.95 percent by ground tankers, 0.22 percent by plows or trenchers, and 0.12 percent by bulldozers (Table IV-5). Only 1.53 percent of the fires attacked with power equipment were class C or larger size.

More than half of the lightning fires are initially attacked by two fire fighters. During the 1960-1974 period 55.68 percent of the fires involved initial attack by two persons including either ground or airborne operations. Only 9.78 percent were attacked by one person. A steadily decreasing number of fires are attacked by more than two persons. Less than one percent of the fires are initially attacked by more than ten fire fighters (Table IV-6).

The strength of initial attack forces varies significantly by size class of fire. Only 0.56 percent of the class A fires were initially attacked by more than ten fire fighters. The studies of initial attack indicate good ability to identify fires with potential for spread to larger size class. For example the initial attack forces of more than 10 fire fighters were as follows (Table IV-6):

| | | |
|---|---|---|
| Class B | 164 fires | 3.42 percent |
| " C | 57 " | 9.13 " |
| " D | 8 " | 8.33 " |
| " E | 6 " | 10.34 " |
| " F | 3 " | 10.34 " |
| " G | 1 " | 6.67 " |

Table IV-5. Number of Lightning Fires by Method of Initial Attack and Size Class in Region Three, 1960-1974.

| Method of Initial Attack | A | B | C | D | E | F | G | Total | Percent of Total Fires |
|---|---|---|---|---|---|---|---|---|---|
| Dozer | 16 | 14 | 3 | 1 | 0 | 0 | 0 | 34 | 0.12 |
| Plow/Trencher | 34 | 25 | 4 | 0 | 0 | 0 | 0 | 63 | 0.22 |
| Ground-Tanker | 1934 | 290 | 17 | 5 | 4 | 2 | 0 | 2252 | 7.95 |
| Ground-Hand | 16144 | 2845 | 332 | 57 | 35 | 18 | 5 | 19436 | 68.58 |
| Heli-Tanker | 5 | 2 | 0 | 1 | 1 | 0 | 0 | 9 | 0.03 |
| Air-Tanker | 277 | 391 | 113 | 16 | 11 | 7 | 2 | 817 | 2.88 |
| Smoke Jumper | 847 | 162 | 8 | 0 | 0 | 0 | 0 | 1017 | 3.59 |
| Helitack | 3477 | 1057 | 147 | 17 | 7 | 1 | 8 | 4714 | 16.63 |
| Total (1) | 22734 | 4786 | 624 | 97 | 58 | 28 | 15 | 28342 | |

(1) Method of Initial Attack not coded for 35 fires

Table IV-6. Number of Lightning Fires by Strength of Initial Attack and Size Class in Region Three, 1960-1974.

| No. of People | A | B | C | D | E | F | G | Total | Percent of Total Fires |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2356 | 361 | 39 | 8 | 4 | 4 | 1 | 2773 | 9.78 |
| 2 | 13525 | 2036 | 178 | 29 | 14 | 6 | 4 | 15792 | 55.68 |
| 3 | 4288 | 905 | 97 | 15 | 8 | 3 | 3 | 5319 | 18.75 |
| 4 | 1453 | 665 | 95 | 11 | 9 | 5 | 1 | 2239 | 7.89 |
| 5 | 513 | 277 | 51 | 7 | 5 | 2 | 0 | 855 | 3.01 |
| 6-10 | 484 | 384 | 107 | 18 | 12 | 6 | 5 | 1016 | 3.58 |
| 11-20 | 79 | 88 | 26 | 4 | 4 | 0 | 1 | 202 | 0.71 |
| 21-30 | 39 | 52 | 15 | 3 | 0 | 1 | 0 | 110 | 0.40 |
| Over 30 | 9 | 24 | 16 | 1 | 2 | 2 | 0 | 54 | 0.19 |
| Total (1) | 22746 | 4792 | 624 | 96 | 58 | 29 | 15 | 28360 | |

(1) No. of people not coded for 17 fires

Fast initial attack following discovery is common for lightning fires in Region Three. As shown in Table IV-7 more than 62 percent of the fires are attacked within one hour following discovery. Moreover 87 percent are attacked within three hours. Only four percent have initial attack times of more than 12 hours. These studies indicate that elapsed time from origin to discovery is a significant factor in the overall speed of attack (see Chapter IV-1).

Table IV-7. Distribution of Lightning Fires by Elapsed Time Discovery to Initial Attack in Each National Forest Zone, 1960-1974.

| Initial Attack Time | NW | SW | Central | Eastern | Total | Percent of Total Fires |
|---|---|---|---|---|---|---|
| 1 hr | 5554 | 2766 | 6594 | 2734 | 17648 | 62.19 |
| 2 hrs | 1452 | 861 | 1688 | 859 | 4860 | 17.13 |
| 3 hrs | 613 | 437 | 752 | 419 | 2221 | 7.83 |
| 4-6 hrs | 411 | 400 | 616 | 394 | 1821 | 6.42 |
| 7-9 hrs | 82 | 128 | 119 | 51 | 380 | 1.34 |
| 10-12 hrs | 60 | 97 | 110 | 57 | 324 | 1.14 |
| 13-24 hrs | 197 | 194 | 423 | 180 | 994 | 3.50 |
| 24-48 hrs | 12 | 13 | 53 | 28 | 106 | 0.37 |
| Over 48 hrs | 3 | 1 | 16 | 3 | 23 | 0.08 |

## IV-3. Fire Suppression Operations

### Reinforcement of Fire Attacks

Nearly one-fourth of the lightning fires require reinforcement of suppression forces following initial attack. During the 15 year study period 6397 lightning fires or 22.55 percent of the total fires attacked were reinforced. As shown in Table IV-8 the fires reinforced increased from a low of 13.17 percent for class A fires to a high of 96.36 percent for class E fires. The variation by national forest zones for all fires reinforced was as follows:

| Zone | % of Fires Reinforced |
|---|---|
| Northwest | 19.70 |
| Southwest | 26.38 |
| Central | 20.97 |
| Eastern | 27.77 |

The primary method of suppression reinforcement is employment of ground forces using hand tools. This method was employed on 54.55 percent of the fires requiring reinforcement action. Other ground forces including dozers, plows, trenchers and tank trucks were used as a primary reinforcement method on 1215 fires accounting for 18.99 percent of the fires. Tank trucks were used on 17.02 percent of the fires reinforced (Table IV-9).

Airborne units play a major role in fire reinforcement operations. Air and heli-tankers, smoke jumpers and helitack fire fighters were primary reinforcement units on 1699 fires accounting for 26.55 percent of the fires. Helitack forces were used on 15.96 percent of the fires and air-tankers on 8.83 percent. These two reinforcement methods were employed on 63 class D or larger fires or 35.59 percent of the large fires requiring reinforcement action (Table IV-9).

Table IV-8. Summary of Lightning Fires Requiring Reinforcement by Size Class in Region Three, 1960-1974.

| | Total No. of Fires | % of Fires Requiring Reinforcement | % of Fires Requiring Reinforcement |
|---|---|---|---|
| A | 22757 | 2996 | 13.17 |
| B | 4787 | 2708 | 56.57 |
| C | 624 | 515 | 82.53 |
| D | 95 | 87 | 91.58 |
| E | 55 | 53 | 96.36 |
| F | 30 | 25 (1) | 83.33 |
| G | 17 | 13 (1) | 76.47 |
| Total | 28365 | 6397 | 22.55 |

(1) As coded on fire reports. It is probable that 100 percent of these fires were reinforced.

Table IV-9. Distribution of Fires by Reinforcement Method and Size Class in Region Three, 1960-1974.

| | Dozer | Trencher | Ground Tanker | Ground Hand | Heli-Tanker | Air Tanker | Smoke-Jumper | Helitack | Total |
|---|---|---|---|---|---|---|---|---|---|
| A | 8 | 28 | 782 | 1707 | 6 | 108 | 36 | 321 | 2996 |
| B | 28 | 52 | 273 | 1429 | 4 | 310 | 58 | 554 | 2708 |
| C | 4 | 3 | 23 | 247 | 1 | 111 | 7 | 119 | 515 |
| D | 0 | 0 | 7 | 47 | 0 | 20 | 1 | 12 | 87 |
| E | 1 | 0 | 4 | 32 | 0 | 10 | 0 | 6 | 53 |
| F | 0 | 2 | 0 | 15 | 0 | 3 | 0 | 5 | 25 |
| G | 0 | 0 | 0 | 6 | 0 | 3 | 0 | 4 | 13 |
| Total | 41 | 85 | 1089 | 3483 | 11 | 565 | 102 | 1021 | 6397 (1) |
| % of Fires | 0.64 | 1.33 | 17.02 | 54.45 | 0.17 | 8.83 | 1.59 | 15.96 | |

(1) Includes only fires with coded data on reinforcement method.

## Summary of Fire Suppression Actions

Fast attack of lightning fires is a dominant feature of fire suppression action in Region Three. During the 1960-1974 period 87 percent of the fires were attacked within three hours and 96 percent within 12 hours. Little variation in speed of attack was noted between national forest zones. The Northwestern Zone had the highest percentage of fires attacked within three hours and 12 hours. The Central Zone had the highest number and percentage of fires with attack times of more than 12 hours. The Eastern Zone had the smallest number and percentage of fires attacked within three hours (Table IV-10).

Elapsed control time for lightning fires is relatively high. Only 36 percent of the fires were controlled within six hours after arrival of suppression forces. Twenty percent of the fires required more than 24 hours for control. The Northwest Zone fires were controlled faster than in any other zone. The Central Zone fires required the longest control times (Table IV-10).

Table IV-10. Summary of Lightning Fire Suppression Action in Each National Forest Zone, 1960-1974.

| | | Fires by Zone | | | | |
|---|---|---|---|---|---|---|
| | | NW | SW | Central | Eastern | Total |
| Initial Attack | | | | | | |
| Within 3 hrs | # | 7619 | 4064 | 9034 | 4012 | 24729 |
| | % | 90.9 | 83.0 | 87.1 | 84.9 | 87.1 |
| Within 12 hrs | # | 8172 | 4689 | 9879 | 4514 | 27254 |
| | % | 97.5 | 95.8 | 95.3 | 95.5 | 96.0 |
| More than 12 hrs | # | 212 | 208 | 492 | 211 | 1123 |
| | % | 2.5 | 4.2 | 4.7 | 4.5 | 4.0 |
| Total | | 8384 | 4897 | 10371 | 4725 | 28377 |
| Control | | | | | | |
| Within 6 hrs | # | 4076 | 1923 | 2966 | 1364 | 10329 |
| | % | 49 | 39 | 29 | 29 | 36 |
| Within 12 hrs | # | 6445 | 3289 | 6012 | 3138 | 18884 |
| | % | 77 | 67 | 58 | 66 | 67 |
| Within 24 hrs | # | 7513 | 3838 | 7641 | 3850 | 22842 |
| | % | 90 | 78 | 74 | 81 | 80 |
| Within 48 hrs | # | 8089 | 4282 | 8933 | 4334 | 25638 |
| | % | 96 | 87 | 86 | 92 | 90 |
| More than 48 hrs | # | 295 | 615 | 1438 | 391 | 2739 |
| | % | 4 | 13 | 14 | 8 | 10 |
| Total | | 8384 | 4897 | 10371 | 4725 | 28377 |

## IV-4. Large Fires

Large fires are very important in terms of impact on costs of fire control and overall planning and management of forest resources and interrelated fire operations. As discussed in other sections of this report lightning is the principal ignition source for large fires in Region Three. Accordingly a special study of these fires has been made to determine the patterns of occurrence, periods of burning, areas burned and personnel requirements in each national forest, wilderness area and zone in Region Three during the 15 year period 1960-1974. Summary data is presented for each fire. The large fires studied include all of the following:

| | |
|---|---|
| Class D | 100 to 299.9 acres in size |
| " E | 300 to 999.9 " " " |
| " F | 1000 to 4999.9 " " " |
| " G | 5000 or more acres |

Less than one percent of the lightning fires account for more than ninety percent of the area burned. During the 1960-74 period 197 lightning fires reached Class D or larger size. This is only 0.69 percent of the total number of lightning fires. These fires burned 333,491 acres accounting for 91.51 percent of the total area burned by lightning fires (Table IV-11).

Great differences exist in the annual occurrence of large lightning fires. In 1972 only three Class D or larger fires occurred. In 1974 a total of 32 large fires were reported. In addition 15 or more large fires occurred in 1960, 1961, 1969, 1970 and 1971. The 15 year average annual occurrence is 13.13, Class D or larger fires (Table IV-12.).

Large lightning fires occur in every month from March through October. June is the leading month for large fires. During the 1960-1974 period 77 Class D or larger fires occurred in June accounting for 39.09 percent of the large fires. May and July are the next leading large fire months with 20.30 and 24.87 percent respectively. More than 84 percent of all large lightning fires occur in the May through July period. Peak loads were 12 large fires in May 1960 and 1961, 15 in June 1971 and 20 in June 1974. Large fires were recorded during August and September in only five years (Table IV-12).

Table IV-11. Summary of Class D or larger Lightning Fires in Each National Forest and Zone, 1960-1974.

| National Forest and Zone | No. of Fires By Size Class | | | | Total Fires | Acres Burned |
|---|---|---|---|---|---|---|
| | D | E | F | G | | |
| Coconino | 6 | 1 | 1 | 0 | 8 | 2,946 |
| Kaibab | 1 | 1 | 0 | 2 | 4 | 17,989 |
| Prescott | 4 | 1 | 0 | 0 | 5 | 1,300 |
| N W Zone TOTAL | 11 | 3 | 1 | 2 | 17 | 22,235 |
| Coronado | 29 | 30 | 14 | 3 | 76 | 85,469 |
| Tonto | 22 | 8 | 4 | 5 | 39 | 57,421 |
| S W Zone TOTAL | 51 | 38 | 18 | 8 | 115 | 142,890 |
| Apache-Sitgreaves | 10 | 2 | 4 | 3 | 19 | 82,357 |
| Gila | 8 | 5 | 1 | 2 | 16 | 39,509 |
| Central Zone TOTAL | 18 | 8 | 4 | 5 | 35 | 121,866 |
| Carson | 0 | 0 | 0 | 0 | 0 | 0 |
| Cibola | 9 | 2 | 4 | 0 | 15 | 8,942 |
| Lincoln | 5 | 2 | 1 | 1 | 9 | 19,283 |
| Santa Fe | 1 | 2 | 2 | 1 | 6 | 18,275 |
| Eastern Zone TOTAL | 15 | 6 | 7 | 2 | 30 | 46,500 |
| Region Three TOTAL | 95 | 54 | 31 | 17 | 197 | 333,491 |

Table IV-12. Number of Class D or Larger Lightning Fires By Year and Month of Occurrence for Region Three, 1960-1974.

| | April | May | June | July | Aug. | Sept. | Oct. | Total | |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | | 12 | 3 | 2 | | | | 17 | |
| 1961 | | 12 | 3 | 1 | | | | 16 | |
| 1962 | 1 | | 5 | 1 | | 1 | | 8 | |
| 1963 | 1 | | 1 | 2 | | | | 4 | |
| 1964 | | | 6 | 3 | 1 | | 1 | 11 | |
| 1965 | | | 1 | 10 | | | | 11 | |
| 1966 | | 3 | 7 | 1 | | | | 11 | |
| 1967 | | 3 | 1 | 3 | | | | 8 | (1) |
| 1968 | | | 8 | 2 | | 2 | 1 | 13 | |
| 1969 | | 5 | 3 | 6 | 8 | 1 | | 23 | |
| 1970 | | 1 | 4 | 7 | 2 | 1 | | 15 | |
| 1971 | 1 | 1 | 15 | 3 | | | | 20 | |
| 1972 | | | | 3 | | | | 3 | |
| 1973 | | | | 1 | 4 | | | 5 | |
| 1974 | | 3 | 20 | 4 | 3 | 2 | | 32 | |
| TOTAL | 3 | 40 | 77 | 49 | 18 | 7 | 2 | 197 | |
| % | 1.52 | 20.30 | 39.09 | 24.87 | 9.13 | 3.55 | 1.02 | | |

(1) 1 fire in March.

Class G lightning fires account for nearly two-thirds of the area burned. Seventeen Class G fires (0.06 percent of the total of all lightning fires) burned 217,039 acres accounting for 59.56 percent of the total area burned. As shown in Table IV-13 seven national forests recorded Class G fires during nine of the fifteen years studied. The Tonto National Forest had five Class G fires. The Apache-Sitgreaves National Forest recorded 68,340 acres burned by three Class G fires with all of them starting on June 14, 1971.

The Southwestern Zone leads all zones in Region Three in both number of large fires and area burned by these fires. In this zone 115 Class D or larger fires burned 152,890 acres during the 15 years studied (Table IV-11.). The Coronado National Forest recorded 76 large fires which burned 85,469 acres. The Tonto National Forest had 39 large fires which burned 57,421 acres. In the Central Zone 35 large fires burned 121,866 acres. The Apache-Sitgreaves National Forest record of 19 large fires burning 82,357 acres was strongly influenced by a 56,790 acre fire starting on June 24, 1971. This was the largest fire recorded in Region Three. A summary of all Class D or larger fires is contained in Table IV-14.

Table IV-13. Summary of Class G Lightning Fires on Individual National Forests.

| Year | Date | Acres Burned | | | | | | | Total for Year |
|---|---|---|---|---|---|---|---|---|---|
| | | Kaibab | Coronado | Tonto | Apache-Sitgreaves | Gila | Lincoln | Santa Fe | |
| 1960 | 5-21 | 8673 | | | | | | | |
| | 7-9 | | | | | 5000 | | | 13,673 |
| 1961 | 5-12 | | 6664 | | | | | | 6,664 |
| 1962 | 7-23 | 8660 | | | | | | | 8,660 |
| 1964 | 6-27 | | | 5000 | | | | | 5,000 |
| 1966 | 5-14 | | | 12720 | | | | | |
| | 6-14 | | | 8000 | | | | | 20,720 |
| 1968 | 6-19 | | 18430 | | | | | | 18,430 |
| 1970 | 7-3 | | | 6300 | | | | | 6,300 |
| 1971 | 6-24 | | | | 6000 | | | | |
| | 6-24 | | | | 5550 | | | | |
| | 6-24 | | | | 56790 | | | | |
| | 6-26 | | | | | | | 12929 | 81,260 |
| 1974 | 6-23 | | | 8320 | | | | | |
| | 6-26 | | 5087 | | | | | | |
| | 6-28 | | | | | 27413 | | | |
| | 6-29 | | | | | | 15512 | | 56,332 |
| **Total Fires** | | 2 | 3 | 5 | 3 | 2 | 1 | 1 | 17 |
| **Total Acres Burned** | | 17,333 | 30,181 | 40,340 | 68,340 | 32,413 | 15,512 | 12,920 | 217,039 |

Table IV-14. Summary of Class D or Larger Lightning Fires in Region Three National Forests, 1960-1974.

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel[1/] |
|---|---|---|---|---|---|---|
| 1960 | 5-2 | 5-2 | Coronado | D | 285 | 2 |
| | 5-2 | 5-5 | " | E | 538 | 58 |
| | 5-2 | 5-4 | " | F | 3148 | 291 |
| | 5-2 | 5-4 | " | F | 2216 | 367 |
| | 5-3 | 5-5 | " | F | 2785 | 284 |
| | 5-5 | 5-5 | " | E | 500 | 16 |
| | 5-19 | 5-21 | " | E | 980 | X |
| | 5-20 | 5-21 | " | F | 1400 | 9 |
| | 5-20 | 5-20 | " | F | 1205 | 100 |
| | 5-20 | 5-20 | Santa Fe | E | 390 | X |
| | 5-21 | 5-28 | Kaibab | G | 8673 | X |
| | 5-23 | 5-23 | Coronado | E | 530 | 57 |
| | 6-2 | 6-2 | " | D | 295 | 150 |
| | 6-16 | 6-16 | " | E | 318 | 95 |
| | 6-20 | 6-20 | Prescott | D | 106 | 6 |
| | 7-5 | 7-7 | " | E | 685 | 300 |
| | 7-9 | 7-9 | Gila | G | 5000 | 25 |
| 1961 | 5-11 | 5-14 | Coronado | F | 2625 | 200 |
| | 5-12 | 5-12 | " | E | 310 | 18 |
| | 5-12 | 5-14 | " | F | 1160 | 65 |
| | 5-12 | 5-15 | " | G | 6664 | X |
| | 5-16 | 5-16 | " | D | 280 | 18 |
| | 5-20 | 5-22 | Tonto | E | 540 | 600 |
| | 5-24 | 5-26 | Apache-Sitgreaves | D | 110 | 290 |
| | 5-25 | 5-25 | Coronado | D | 263 | X |
| | 5-26 | 5-26 | " | D | 180 | X |
| | 5-27 | 5-28 | Apache-Sitgreaves | D | 210 | 235 |

[1/] As coded on fire reports. X = unknown

Table IV-14. (cont.)

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel |
|---|---|---|---|---|---|---|
| 1961 (cont) | 5-28 | 5-28 | Kaibab | D | 211 | 110 |
| | 5-30 | 5-30 | Coronado | D | 160 | 6 |
| | 6-10 | 6-10 | " | D | 240 | 60 |
| | 6-11 | 6-15 | " | D | 252 | 252 |
| | 6-20 | 6-20 | Cibula | F | 1088 | X |
| | 7-11 | 7-11 | Coconino | D | 148 | 23 |
| 1962 | 4-27 | 4-29 | Coronado | D | 280 | 18 |
| | 6-9 | 6-9 | Santa Fe | F | 1585 | X |
| | 6-26 | 6-26 | Coronado | D | 277 | 40 |
| | 6-26 | 6-26 | " | D | 100 | 15 |
| | 6-26 | 6-26 | " | D | 285 | 40 |
| | 6-26 | 6-27 | " | E | 500 | 16 |
| | 7-23 | 7-23 | Kaibab | G | 8660 | 813 |
| | 9-19 | 9-19 | Tonto | D | 225 | 50 |
| 1963 | 4-15 | 4-15 | Santa Fe | D | 270 | X |
| | 6-14 | 6-14 | " | F | 1585 | 85 |
| | 7-25 | 7-25 | Cibola | F | 1088 | 27 |
| | 7-26 | 7-26 | " | D | 105 | X |
| 1964 | 6-25 | 6-25 | Coconino | D | 260 | 18 |
| | 6-25 | 6-25 | Prescott | D | 127 | 9 |
| | 6-25 | 6-25 | Tonto | D | 120 | 23 |
| | 6-27 | 7-1 | " | F | 5000 | 185 |
| | 6-27 | 6-27 | Gila | D | 135 | X |
| | 6-28 | 6-29 | Coronado | E | 500 | 170 |
| | 7-4 | 7-4 | Lincoln | D | 159 | 43 |
| | 7-12 | 7-12 | Prescott | D | 262 | 19 |
| | 7-12 | 7-12 | Tonto | D | 267 | 10 |
| | 8-22 | 8-22 | Apache-Sitgreaves | D | 120 | 36 |
| | 10-25 | 10-30 | " | D | 281 | 5 |

Table IV-14. (cont.)

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel |
|---|---|---|---|---|---|---|
| 1965 | 6-24 | 6-24 | Tonto | E | 305 | 57 |
| | 7-5 | 7-7 | Coronado | E | 545 | 79 |
| | 7-5 | 7-5 | " | E | 352 | X |
| | 7-5 | 7-5 | " | E | 506 | 37 |
| | 7-5 | 7-5 | " | F | 1722 | 180 |
| | 7-5 | 7-7 | " | E | 642 | 29 |
| | 7-6 | 7-6 | " | D | 288 | 5 |
| | 7-7 | 7-7 | Tonto | F | 2510 | 600 |
| | 7-11 | 7-11 | " | D | 106 | 33 |
| | 7-13 | 7-13 | " | D | 132 | 190 |
| 1966 | 5-1 | 5-1 | Cibola | D | 165 | 6 |
| | 5-14 | 5-19 | Tonto | G | 12720 | 380 |
| | 5-23 | 5-23 | Lincoln | D | 133 | X |
| | 6-14 | 6-16 | Coronado | E | 450 | X |
| | 6-14 | 6-19 | Tonto | G | 8000 | 150 |
| | 6-14 | 6-16 | " | D | 125 | 35 |
| | 6-15 | 6-15 | Coronado | E | 320 | X |
| | 6-15 | 6-15 | " | D | 190 | 4 |
| | 6-16 | 6-17 | " | F | 1030 | 61 |
| | 6-18 | 6-19 | Kaibab | E | 445 | X |
| | 7-16 | 7-16 | Tonto | D | 101 | 36 |
| 1967 | 3-23 | 3-23 | Coronado | E | 432 | X |
| | 5-8 | 5-9 | Coconino | E | 865 | 300 |
| | 5-18 | 5-18 | Coronado | D | 250 | 70 |
| | 5-19 | 5-21 | Apache-Sitgreaves | F | 2947 | 283 |
| | 6-21 | 6-21 | Coconino | F | 1000 | 305 |
| | 7-2 | 7-2 | Tonto | D | 120 | 81 |
| | 7-2 | 7-3 | Cibola | E | 310 | 250 |
| | 7-4 | 7-4 | Gila | E | 712 | 15 |

Table IV-14. (cont.)

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel |
|---|---|---|---|---|---|---|
| 1968 | 6-3 | 6-3 | Apache-Sitgreaves | D | 112 | 6 |
| | 6-19 | 6-22 | Coronado | F | 4060 | 129 |
| | 6-19 | 6-20 | " | E | 307 | 60 |
| | 6-19 | 6-21 | " | E | 480 | 35 |
| | 6-19 | 6-25 | " | G | 18430 | 500 |
| | 6-20 | 6-20 | " | D | 230 | 91 |
| | 6-21 | 6-22 | Apache-Sitgreaves | F | 2143 | 121 |
| | 6-22 | 6-22 | " | E | 369 | 192 |
| | 7-18 | 7-19 | Coronado | D | 130 | 32 |
| | 7-20 | 7-20 | Coconino | D | 188 | 3 |
| | 9-26 | 9-27 | Coronado | E | 605 | 171 |
| | 9-29 | 9-29 | " | D | 120 | 9 |
| | 10-15 | 10-17 | " | D | 118 | 177 |
| 1969 | 5-12 | 5-12 | Prescott | D | 120 | 14 |
| | 5-23 | 5-25 | Gila | D | 180 | 165 |
| | 5-23 | 5-26 | " | E | 970 | 71 |
| | 5-23 | 5-23 | " | D | 172 | 15 |
| | 5-30 | 5-30 | " | D | 230 | 42 |
| | 6-5 | 6-5 | Coronado | E | 365 | 15 |
| | 6-5 | 6-6 | Tonto | D | 170 | 65 |
| | 6-6 | 6-6 | Coronado | D | 110 | 81 |
| | 7-1 | 7-2 | " | D | 280 | 30 |
| | 7-1 | 7-2 | " | E | 380 | 54 |
| | 7-2 | 7-2 | " | D | 160 | 33 |
| | 7-2 | 7-4 | " | F | 1970 | 475 |
| | 7-4 | 7-6 | " | E | 320 | 120 |
| | 7-5 | 7-5 | Cibola | E | 310 | 51 |
| | 8-1 | 8-1 | Tonto | D | 150 | 7 |

Table IV-14. (cont.)

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel |
|---|---|---|---|---|---|---|
| 1969 (cont) | 8-2 | 8-2 | Tonto | E | 310 | 14 |
| | 8-4 | 8-5 | Coronado | E | 470 | 56 |
| | 8-4 | 8-5 | " | D | 280 | 215 |
| | 8-4 | 8-5 | Tonto | E | 800 | 15 |
| | 8-5 | 8-5 | " | D | 230 | 14 |
| | 8-8 | 8-11 | Apache-Sitgreaves | D | 250 | 57 |
| | 8-22 | 8-23 | Tonto | D | 260 | 22 |
| | 9-5 | 9-6 | " | D | 220 | 24 |
| 1970 | 5-28 | 5-29 | Apache-Sitgreaves | D | 230 | 134 |
| | 6-26 | 6-26 | Tonto | D | 180 | 45 |
| | 6-26 | 6-26 | Gila | D | 210 | 39 |
| | 6-28 | 6-28 | Coronado | E | 497 | 80 |
| | 6-28 | 6-28 | " | E | 690 | 30 |
| | 7-3 | 7-7 | Tonto | G | 6300 | 318 |
| | 7-3 | 7-6 | " | F | 4700 | 448 |
| | 7-3 | 7-6 | " | F | 2400 | 281 |
| | 7-4 | 7-5 | " | E | 650 | 40 |
| | 7-6 | 7-6 | " | E | 540 | 2 |
| | 7-9 | 7-9 | Coronado | E | 590 | 30 |
| | 7-27 | 7-27 | Tonto | D | 160 | 50 |
| | 8-7 | 8-26 | Gila | E | 900 | 6 |
| | 8-31 | 9-1 | Coronado | D | 182 | 60 |
| | 9-16 | 9-20 | Gila | F | 1400 | 6 |
| 1971 | 4-5 | 4-6 | " | E | 878 | 193 |
| | 5-26 | 5-26 | Lincoln | F | 1575 | 72 |
| | 6-16 | 6-17 | Coronado | E | 322 | 112 |
| | 6-17 | 6-17 | Apache-Sitgreaves | D | 150 | 16 |

Table IV-14. (cont.)

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel |
|---|---|---|---|---|---|---|
| 1971 (cont) | 6-17 | 6-17 | Coconino | D | 150 | 25 |
| | 6-18 | 6-18 | Apache-Sitgreaves | E | 550 | 30 |
| | 6-19 | 6-19 | Lincoln | D | 200 | 36 |
| | 6-22 | 6-23 | Cibola | D | 100 | 36 |
| | 6-23 | 6-24 | Apache-Sitgreaves | D | 270 | 120 |
| | 6-24 | 6-31 | " | F | 1900 | 300 |
| | 6-24 | 6-27 | " | F | 4100 | 400 |
| | 6-24 | 6-31 | " | G | 6000 | 500 |
| | 6-24 | 6-26 | Coronado | F | 1210 | 130 |
| | 6-24 | 6-28 | Apache-Sitgreaves | G | 5550 | 772 |
| | 6-24 | 7-2 | " | G | 56790 | 2440 |
| | 6-26 | 6-30 | Santa Fe | G | 12920 | 1454 |
| | 6-30 | 6-30 | Lincoln | D | 115 | 13 |
| | 7-11 | 7-12 | Coronado | F | 1400 | 50 |
| | 7-13 | 7-15 | Tonto | D | 130 | 428 |
| | 7-15 | 7-17 | Coconino | D | 135 | 45 |
| 1972 | 7-1 | 7-2 | Coronado | D | 130 | 88 |
| | 7-2 | 7-2 | Cibola | F | 2640 | 30 |
| | 7-16 | 7-16 | Coronado | D | 290 | 12 |
| 1973 | 7-4 | 7-4 | Cibola | D | 164 | 8 |
| | 8-3 | 8-3 | Tonto | E | 300 | 6 |
| | 8-14 | 8-14 | " | D | 125 | 51 |
| | 8-14 | 8-14 | " | D | 120 | 10 |
| | 8-23 | 8-23 | " | D | 240 | 47 |
| 1974 | 5-10 | 5-11 | Santa Fe | F | 1525 | 290 |
| | 5-27 | 5-27 | Gila | E | 750 | 42 |

Table IV-14. (cont.)

| Year | Date Start | Date Control | Nat'l Forest | Size Class | Acres Burned | No. of Personnel |
|---|---|---|---|---|---|---|
| 1974 (cont) | 5-27 | 5-28 | Lincoln | E | 408 | 433 |
| | 6-3 | 6-4 | " | D | 256 | 250 |
| | 6-15 | 6-15 | Tonto | D | 175 | 2 |
| | 6-16 | 6-16 | Coronado | E | 420 | 70 |
| | 6-23 | 7-1 | Tonto | G | 8320 | 33 |
| | 6-24 | 6-24 | Coronado | E | 410 | 36 |
| | 6-25 | 7-2 | " | D | 120 | 1672 |
| | 6-25 | 6-25 | Cibola | D | 202 | 105 |
| | 6-25 | 6-29 | " | D | 275 | 476 |
| | 6-26 | 7-1 | Coronado | G | 5087 | 1672 |
| | 6-27 | 6-28 | " | E | 540 | 39 |
| | 6-27 | 6-28 | " | E | 344 | 9 |
| | 6-28 | 6-31 | Gila | D | 249 | 31 |
| | 6-28 | 6-31 | " | G | 27413 | 406 |
| | 6-29 | 6-31 | Coronado | F | 2400 | 32 |
| | 6-29 | 6-29 | Cibola | D | 102 | 34 |
| | 6-29 | 6-30 | " | E | 670 | 450 |
| | 6-29 | 6-29 | " | D | 168 | 3 |
| | 6-29 | 7-3 | Lincoln | G | 15512 | 660 |
| | 6-29 | 6-30 | " | E | 925 | 70 |
| | 6-30 | 6-30 | Apache-Sitgreaves | D | 278 | 22 |
| | 7-1 | 7-1 | Coronado | D | 155 | 9 |
| | 7-1 | 7-2 | " | D | 150 | 39 |
| | 7-1 | 7-1 | Cibola | D | 108 | 57 |
| | 7-2 | 7-2 | Gila | D | 135 | 17 |
| | 8-9 | 8-9 | Tonto | D | 200 | 35 |
| | 8-23 | 8-23 | Coconino | D | 200 | 24 |
| | 8-23 | 8-24 | Tonto | D | 120 | 114 |
| | 9-8 | 9-10 | Gila | D | 175 | 55 |
| | 9-17 | 9-17 | Tonto | E | 350 | 21 |

# V. LIGHTNING FIRES IN WILDERNESS

Lightning fires in wilderness areas are of special interest to fire and overall resource management. In keeping with the objectives of wilderness area designation it is desirable to have selected fires play a natural role in wilderness ecosystems. Obviously these are lightning fires. Selection of the fires to be allowed to burn involves consideration of many factors including possible spread of these fires to other areas, effects on other resources, safety of people, problems of multiple ignitions in short periods of time and the impacts on the total fire load at given times and places. Accordingly, to provide information for possible use in fire management planning and decision making special studies were made of lightning fires in the wilderness areas of Region Three.

In this research special computer programs were utilized to identify lightning fires occurring in present wilderness and primitive areas and wilderness study areas designated by the Chief of the Forest Service (U.S. Forest Service, October 15, 1974). The total area studied includes 1,690, 240 acres in wilderness and primitive areas and 825,531 acres in wilderness study areas. The total area of 2,551,771 acres amounts to 11.52 percent of the national forest areas in Region Three. This total wilderness area does not include the possible additions under the RARE II program. Constraints on coded fire report information restricted the study period to fires occurring in the years of 1960, 1961 and 1970 through 1974.

## V-1. Wilderness Fire Phenomena

Nearly 2500 lightning fires occurred in wilderness during a seven year period. As shown in Table I-1 1936 fires occurred in wilderness and primitive areas and 551 fires in wilderness study areas. This amounts to 15.16 percent of the lightning fires in Region Three during the years 1960, 1961 and 1970 through 1974. The annual occurrence of wilderness lightning fires varied from a low of 219 fires in 1973 to a high of 436 fires in 1961. Fires in all of the various wilderness designations accounted for 19.92 percent of the class C or larger fires in the region during the seven year study period.

Lightning fires in wilderness burned more than 12,000 acres. The area burned includes 4072 acres in wilderness and primitive areas and 7949 acres in wilderness study areas (Table I-1). This amounts to 4.93 percent of the area burned in the region. The area burned in a single year in all wilderness designations varied from a low of 78 acres in 1972 to a high of 6595 acres in 1970. The area burned in 1970 amounted to 54.86 percent of the total area burned by wilderness fires in the seven year study period.

Wilderness fires are smaller in average size than non-wilderness fires. The average size of lightning fires in all of the various wilderness designations was only 4.83 acres as compared to 16.70 acres for non-wilderness fires. The average size of wilderness fires varied from 2.10 acres in designated wilderness and primitive areas to 14.43 acres in wilderness study areas (Table V-1).

Peak lightning fire occurrence in wilderness areas is in July. During the seven years studied 934 fires occurred in July accounting for 37.56 percent of the total. July was the peak month of lightning fire occurrence in both wilderness and primitive areas and wilderness study areas (Table V-2). June was the second leading month for lightning fire occurrence with 28.39 percent of the fires. This monthly occurrence pattern in wilderness follows the same general distribution as found for lightning fires in the entire region except that in wilderness there are more fires in May and fewer in August. The peak monthly load in a single year in wilderness was 203 fires in May 1961.

Table V-1. Number of Lightning Fires by Size Class and Acres Burned In Wilderness and Primitive Areas, Wilderness Study Areas and Non-Wilderness Areas, 1960-1961 and 1970-1974.

| Year | Area [1/] | Size Class A | B | C | D | Et | Total Fires | Acres Burned |
|---|---|---|---|---|---|---|---|---|
| 1960 | WPA | 193 | 52 | 5 | | | 250 | 181 |
| | WSA | 61 | 11 | 2 | | 2 | 76 | 1371 |
| | NWA | 1879 | 293 | 33 | 3 | 12 | 2220 | 29938 |
| | Total | 2133 | 356 | 40 | 3 | 14 | 2546 | 31490 |
| 1961 | WPA | 294 | 44 | 1 | 1 | | 340 | 393 |
| | WSA | 68 | 25 | 3 | | | 96 | 117 |
| | NWA | 2026 | 326 | 38 | 9 | 6 | 2405 | 15911 |
| | Total | 2388 | 395 | 42 | 10 | 6 | 2841 | 16421 |
| 1970 | WPA | 213 | 87 | 5 | 2 | 1 | 308 | 1491 |
| | WSA | 50 | 25 | 7 | 1 | 1 | 84 | 5104 |
| | NWA | 1383 | 371 | 44 | 2 | 9 | 1809 | 15181 |
| | Total | 1646 | 483 | 56 | 5 | 11 | 2201 | 21776 |
| 1971 | WPA | 189 | 100 | 12 | | | 301 | 428 |
| | WSA | 43 | 24 | 2 | 1 | | 70 | 248 |
| | NWA | 1489 | 427 | 45 | 7 | 12 | 1980 | 95985 |
| | Total | 1721 | 551 | 59 | 8 | 12 | 2351 | 96661 |
| 1972 | WPA | 231 | 37 | 1 | | | 269 | 26 |
| | WSA | 70 | 18 | 1 | | | 89 | 52 |
| | NWA | 1795 | 284 | 22 | 2 | 1 | 2104 | 3721 |
| | Total | 2096 | 339 | 24 | 2 | 1 | 2462 | 3799 |
| 1973 | WPA | 128 | 37 | 5 | | | 170 | 92 |
| | WSA | 35 | 12 | 2 | | | 49 | 39 |
| | NWA | 1130 | 260 | 33 | 4 | 1 | 1428 | 1979 |
| | Total | 1293 | 309 | 40 | 4 | 1 | 1647 | 2110 |
| 1974 | WPA | 187 | 79 | 31 | 1 | | 298 | 1461 |
| | WSA | 60 | 17 | 7 | 3 | | 87 | 1018 |
| | NWA | 1500 | 370 | 79 | 13 | 15 | 1977 | 69855 |
| | Total | 1747 | 466 | 117 | 17 | 15 | 2362 | 72334 |
| Total | WPA | 1435 | 436 | 60 | 4 | 1 | 1936 | 4072 |
| | WSA | 387 | 132 | 24 | 5 | 3 | 551 | 7949 |
| | NWA | 11202 | 2331 | 294 | 40 | 56 | 13923 | 232570 |
| | Total | 13024 | 2899 | 378 | 49 | 60 | 16410 | 244591 |

[1/] WPA = Wilderness and Primitive Areas
WSA = Wilderness Study Areas
NWA = Wilderness Areas

Table V-2. Number of Lightning Fires by Months in Wilderness, Primitive and Wilderness Study Areas in Region Three, 1960-1961 and 1970-1974.

| Year | Area[1/] | April | May | June | July | August | Sept. |
|---|---|---|---|---|---|---|---|
| 1960 | WPA | 0 | 59 | 74 | 87 | 23 | 6 |
| | WSA | 1 | 19 | 25 | 22 | 8 | 1 |
| | Total | 1 | 78 | 99 | 109 | 31 | 7 |
| 1961 | WPA | 0 | 170 | 35 | 39 | 2 | 3 |
| | WSA | 5 | 33 | 15 | 18 | 4 | 3 |
| | Total | 5 | 203 | 50 | 57 | 6 | 6 |
| 1970 | WPA | 0 | 12 | 145 | 126 | 15 | 10 |
| | WSA | 0 | 0 | 27 | 52 | 5 | 1 |
| | Total | 0 | 12 | 172 | 178 | 20 | 11 |
| 1971 | WPA | 4 | 8 | 109 | 108 | 54 | 17 |
| | WSA | 1 | 1 | 13 | 41 | 12 | 2 |
| | Total | 5 | 9 | 122 | 149 | 66 | 19 |
| 1972 | WPA | 0 | 19 | 81 | 124 | 40 | 5 |
| | WSA | 0 | 12 | 25 | 38 | 12 | 2 |
| | Total | 0 | 31 | 106 | 162 | 52 | 7 |
| 1973 | WPA | 0 | 18 | 16 | 90 | 36 | 9 |
| | WSA | 0 | 2 | 8 | 26 | 11 | 1 |
| | Total | 0 | 20 | 24 | 116 | 47 | 10 |
| 1974 | WPA | 0 | 12 | 103 | 132 | 22 | 29 |
| | WSA | 0 | 4 | 30 | 31 | 12 | 10 |
| | Total | 0 | 16 | 133 | 163 | 34 | 39 |
| Total | WPA | 4 | 298 | 563 | 706 | 192 | 79 |
| | WSA | 7 | 71 | 143 | 228 | 64 | 20 |
| | Total | 11 | 369 | 706 | 934 | 256 | 99 |

[1/] WPA = Wilderness and Primitive Areas
WSA = Wilderness Study Areas

Ten or more wilderness lightning fires have occurred in a single day on 64 occasions. This level of lightning fire occurrence in a single day varied from a low of three days in 1973 to a high of 14 days in 1962. The peak single day occurrence was 34 lightning fires on July 19, 1970. Twenty or more lightning fires occurred on seven separate days (Table V-3).

Peak wilderness lightning fire loads of more than 40 fires in a three to seven day period have occurred on five occasions. As shown in Table V-3 these peak loads occurred as follows:

| | | |
|---|---|---|
| May 24-28, 1961 | 79 fires | 13.17 fires per day |
| July 7-9, 1970 | 45 " | 15.00 " |
| July 18-20, 1970 | 65 " | 21.67 " |
| June 23-26, 1971 | 62 " | 15.50 " |
| June 24-30, 1974 | 112 " | 16.00 " |

Thirteen Class D or larger fires occurred in wilderness during the seven year study period. A summary of each fire is contained in Table V-4. These fires burned a total of 8558 acres accounting for 71.14 percent of the area burned in wilderness, primitive and wilderness study areas. The largest fire burning 4700 acres occurred July 3, 1970 in the Alder Creek Wilderness Study Area, Tonto National Forest. The Gila Wilderness Area, Blue Range Primitive Area and Alder Creek Wilderness Study Area each had two large fires. The distribution of large fires was as follows:

| | Size Class | | | | |
|---|---|---|---|---|---|
| | D | E | F | Total | Acres Burned |
| Wilderness and Primitive Areas | 4 | 1 | | 5 | 1697 |
| Wilderness Study Areas | 5 | 2 | 1 | 8 | 6861 |
| Total | 9 | 3 | 1 | 13 | 8558 |

Table V-3. Summary of Fire Load on Days When Ten or More Lightning Fires Started in Wilderness, Primitive and Wilderness Study Areas 1960-1961 and 1970-1974.

| | | Wilderness and Primitive Areas | | Wilderness Study Areas | | Total | |
|---|---|---|---|---|---|---|---|
| Year | Date | No. of Fires | Acres Burned | No. of Fires | Acres Burned | No. of Fires | Acres Burned |
| 1960 | 5-5 | 13 | 18 | 3 | 5 | 16 | 23 |
| | 6-18 | 11 | 2 | 4 | 0 | 15 | 2 |
| | 6-30 | 10 | 7 | 2 | 1 | 12 | 8 |
| | 7-4 | 10 | 6 | | | 10 | 6 |
| | 7-6 | 13 | 40 | 2 | 0 | 15 | 40 |
| | 7-10 | 8 | 8 | 2 | 0 | 10 | 8 |
| 1961 | 5-16 | 27 | 1 | 4 | 0 | 31 | 1 |
| | 5-17 | 14 | 0 | 3 | 4 | 17 | 4 |
| | 5-20 | 8 | 0 | 3 | 0 | 11 | 0 |
| | 5-24 | 11 | 4 | 7 | 6 | 18 | 10 |
| | 5-25 | 10 | 1 | 3 | 0 | 13 | 1 |
| | 5-26 | 15 | 4 | 2 | 0 | 17 | 4 |
| | 5-27 | 16 | 222 | 1 | 0 | 17 | 222 |
| | 5-28 | 14 | 0 | | | 14 | 0 |
| | 6-1 | 10 | 3 | 2 | 0 | 12 | 3 |
| | 6-6 | 11 | 0 | | | 11 | 0 |
| | 6-10 | 8 | 0 | 3 | 0 | 11 | 0 |
| | 6-14 | 10 | 0 | | | 10 | 0 |
| | 6-29 | 7 | 0 | 3 | 2 | 10 | 2 |
| | 6-30 | 12 | 0 | 3 | 0 | 15 | 0 |
| 1970 | 6-4 | 11 | 0 | 3 | 0 | 14 | 0 |
| | 6-5 | 9 | 0 | 5 | 27 | 14 | 27 |
| | 6-21 | 18 | 0 | | | 18 | 0 |
| | 6-23 | 13 | 0 | 1 | 0 | 14 | 0 |
| | 6-26 | 20 | 0 | | | 21 | 0 |
| | 6-27 | 20 | 12 | | | 20 | 12 |
| | 7-7 | 10 | 0 | 5 | 0 | 15 | 0 |

Table V-3. (cont.)

| Year | Date | No. of Fires | Acres Burned | No. of Fires | Acres Burned | No. of Fires | Acres Burned |
|---|---|---|---|---|---|---|---|
| 1970 (cont) | 7-8 | 12 | 0 | 6 | 0 | 18 | 0 |
| | 7-9 | 8 | 0 | 4 | 0 | 12 | 0 |
| | 7-18 | 12 | 0 | 9 | 0 | 21 | 0 |
| | 7-19 | 26 | 0 | 8 | 35 | 34 | 35 |
| | 7-20 | 7 | 0 | 3 | 0 | 10 | 0 |
| 1971 | 6-16 | 11 | 0 | 4 | 0 | 15 | 0 |
| | 6-17 | 11 | 0 | | | 11 | 0 |
| | 6-23 | 12 | 0 | 2 | 0 | 14 | 0 |
| | 6-24 | 23 | 0 | | | 23 | 0 |
| | 6-25 | 14 | 0 | 1 | 0 | 15 | 0 |
| | 6-26 | 70 | | 3 | 0 | 10 | 0 |
| | 7-1 | 14 | 60 | | | 14 | 60 |
| | 7-19 | 7 | 0 | 4 | 0 | 11 | 0 |
| | 8-1 | 12 | 18 | | | 12 | 18 |
| 1972 | 6-3 | 14 | 0 | 2 | 0 | 16 | 0 |
| | 6-11 | 15 | 0 | 2 | 0 | 17 | 0 |
| | 7-5 | 12 | 0 | 2 | 52 | 14 | 52 |
| | 7-6 | 11 | 0 | 3 | 0 | 14 | 0 |
| | 7-7 | 13 | 0 | 4 | 0 | 17 | 0 |
| | 7-10 | 8 | 0 | 3 | 0 | 11 | 0 |
| | 7-15 | 9 | 0 | 1 | 0 | 10 | 0 |
| | 7-16 | 14 | 0 | | | 14 | 0 |
| | 8-5 | 11 | 0 | 1 | 0 | 12 | 0 |
| 1973 | 7-3 | 8 | 0 | 3 | 0 | 11 | 0 |
| | 7-7 | 15 | 0 | 1 | 0 | 16 | 0 |
| | 7-8 | 18 | 0 | 3 | 0 | 21 | 0 |
| 1974 | 6-24 | 12 | 108 | 4 | 0 | 16 | 108 |
| | 6-25 | 10 | 34 | 4 | 275 | 14 | 309 |
| | 6-26 | 11 | 0 | 3 | 0 | 14 | 0 |
| | 6-27 | 16 | 20 | 1 | 0 | 17 | 20 |

Table V-3. (cont.)

| Year | Date | No. of Fires | Acres Burned | No. of Fires | Acres Burned | No. of Fires | Acres Burned |
|---|---|---|---|---|---|---|---|
| 1974 (cont) | 6-28 | 22 | 34 | 1 | 0 | 23 | 34 |
| | 6-29 | 14 | 229 | 2 | 0 | 16 | 229 |
| | 6-30 | 7 | 95 | 5 | 0 | 12 | 95 |
| | 7-1 | 8 | 25 | 2 | 0 | 10 | 25 |
| | 7-2 | 22 | 0 | 3 | 0 | 25 | 0 |
| | 7-3 | 19 | 0 | 3 | 0 | 22 | 0 |
| | 7-9 | 9 | 15 | 1 | 0 | 10 | 15 |

Table V-4. Summary of Class D or Larger Lightning Fires in Wilderness, Primitive and Wilderness Study Areas, 1960-1961 and 1970-1974.

| Year | Date | Wilderness Area and Forest | Size Class | Acres Burned | Total Lightning Fires On Forest | Total Lightning Fires In Region |
|---|---|---|---|---|---|---|
| 1960 | 5-23 | Portal Peak WSA (Coronado) | E | 530 | 3 | 24 |
| | 7-5 | Castle Creek WSA (Prescott) | E | 685 | 4 | 33 |
| 1961 | 5-27 | Blue Range PA (Apache) | D | 210 | 4 | 62 |
| 1970 | 5-28 | Blue Range PA (Apache) | D | 230 | 5 | 14 |
| | 7-3 | Alder Creek WSA (Tonto) | F | 4700 | 23 | 48 |
| | 7-27 | Superstition Adn. WSA (Tonto) | D | 160 | 2 | 10 |
| | 8-7 | Gila WA (Gila) | E | 900 | 10 | 10 |
| | 8-31 | Galiuro WA (Coronado) | D | 182 | 1 | 7 |
| 1971 | 7-15 | Secret Mtn. Red Rock WSA (Coconino) | D | 135 | 17 | 55 |
| 1974 | 6-3 | S. Guadalupe Mtns. WSA (Lincoln) | D | 256 | 2 | 23 |
| | 6-25 | Apache Kid WSA (Cibola) | D | 275 | 3 | 71 |
| | 8-23 | Alder Creek WSA (Tonto) | D | 120 | 8 | 23 |
| | 9-8 | Gila WA (Gila) | D | 175 | 4 | 13 |

More than 85 percent of the wilderness lightning fires occur at elevations above 8500 feet. In the Wilderness and Primitive Areas 87.71 percent of the fires were above 6500 feet with the peak occurrence zone between 6501 and 7500 feet. The same general pattern is found in the Wilderness Study Areas with 75.86 percent of the fires above 6500 feet (Table V-5).

More than 50 percent of the wilderness lightning fires occur in ponderosa pine. In all types of wilderness areas ponderosa pine stands are the dominant zone of lightning fire occurrence. Grass and mixed conifer cover types rank second and third respectively in the wilderness, primitive and wilderness study areas. Relatively few fires occur in brush, woodland, spruce and aspen types (Table V-6).

Nearly 45 percent of the wilderness lightning fires occur in high rate-of-spread fuels. As shown in Table V-7 a total of 1108 fires occurred in high rate-of-spread fuels accounting for 44.62 percent of the fires in both wilderness and primitive areas and wilderness study areas. Extreme rate-of-spread fuels accounted for 18.87 percent of the fires in wilderness and primitive areas and 17.30 percent in wilderness areas. On 61.86 percent of the wilderness fires fuels were classified as medium in resistance-to-control. A very high total of 340 fires had fuels classified as extreme in both rate-of-spread and resistance-to-control.

Table V-5. Distribution of Wilderness Lightning Fires by Elevation Zone, 1960-1961 and 1970-1974.

| | Wilderness and Primitive Areas | Wilderness Study Areas | Total | |
|---|---|---|---|---|
| | No. Fires | No. Fires | No. | % |
| 500-2500 | 3 | 4 | 7 | 0.28 |
| 2501-3500 | 5 | 7 | 12 | 0.48 |
| 3501-4500 | 20 | 13 | 33 | 1.33 |
| 4501-5500 | 33 | 37 | 70 | 2.81 |
| 5501-6500 | 177 | 72 | 249 | 10.01 |
| 6501-7500 | 640 | 190 | 830 | 33.37 |
| 7500-8500 | 783 | 137 | 920 | 36.99 |
| Over 8500 | 275 | 91 | 366 | 14.72 |
| Total | 1936 | 551 | 2487 | |

Table V-6. Distribution of Wilderness Lightning Fires by Cover Type, 1960-1961 and 1970-1974.

| | Wilderness and Primitive Areas | Wilderness Study Areas | Total | |
|---|---|---|---|---|
| | No. Fires | No. Fires | No. | % |
| Grass | 631 | 178 | 809 | 32.73 |
| Spruce | 16 | 6 | 22 | 0.89 |
| Mixed Conifer | 177 | 63 | 240 | 9.71 |
| Brush | 62 | 28 | 90 | 3.64 |
| Ponderosa Pine | 999 | 240 | 1239 | 50.12 |
| Aspen | 6 | 2 | 8 | 0.32 |
| Woodland | 41 | 23 | 64 | 2.59 |
| Total | 1932 | 540 | 2472[1/] | |

[1/] Total number of fires with cover type coded

Table V-7. Distribution of Wilderness Lightning Fires by Fuel Rate-of-Spread and Resistance-to-Control Classification, 1960-1961 and 1970-1974.

| Rate-of-Spread | Res.-to-Control | Wilderness and Primitive Areas | Wilderness Study Areas | Total | |
|---|---|---|---|---|---|
| | | No. Fires | No. Fires | No. | % |
| Low | Low | 47 | 56 | | |
| | Medium | 78 | 15 | | |
| | High | 12 | 6 | | |
| | Extreme | 0 | 0 | | |
| Low | Total | 137 | 77 | 214 | 8.62 |
| Medium | Low | 5 | 3 | | |
| | Medium | 560 | 117 | | |
| | High | 4 | 12 | | |
| | Extreme | 0 | 0 | | |
| Medium | Total | 569 | 132 | 701 | 28.23 |
| High | Low | 1 | 4 | | |
| | Medium | 631 | 120 | | |
| | High | 190 | 110 | | |
| | Extreme | 41 | 11 | | |
| High | Total | 863 | 245 | 1108 | 44.62 |
| Extreme | Low | 33 | 15 | | |
| | Medium | 6 | 9 | | |
| | High | 26 | 31 | | |
| | Extreme | 300 | 40 | | |
| Extreme | Total | 365 | 95 | 460 | 18.53 |
| Grand Total | | 1934 | 549 | 2483 | |

## V-2. The Wilderness Fire Load

### Wilderness and Primitive Areas

The combined Gila Wilderness and Primitive Areas Account for more than half of the lightning fires. During the seven year study period 1000 lightning fires occurred in these areas on the Gila National Forest accounting for 51.65 percent of the total in the designated Wilderness and Primitive Areas. Also the Gila areas lead in area burned with 2028 acres or 49.80 percent of the total (Table V-8).

More than 300 lightning fires occurred in two other Primitive Areas. As shown in Table V-8 the Blue Range Primitive Area on the Apache National Forest had 320 fires and the Black Range Primitive Area on the Gila National Forest had 316 fires. The area burned on the Blue Range was 947 acres, second highest among the designated Wilderness and Primitive Areas. The area burned on the Black Range was only 91 acres.

Wilderness and Primitive Areas on the Apache and Gila National Forests Recorded 85 percent of the lightning fires and 75 percent of the area burned. A summary of these concentrations of wilderness fires on the two national forests is shown in Table V-9. The fire occurrence exceeded 170 fires in a single year on six occasions in the two areas on the Gila National Forest. More than 50 fires were recorded in three years on the Blue Range Primitive Area of the Apache National Forest. Burns of more than 300 acres in a single year were recorded in 1970 and 1974 on the Gila and in 1970 on the Apache.

The peak single day lightning fire occurrence has been recorded in the Gila Wilderness Area. The Gila is the only wilderness or primitive area to record more than 15 lightning fires in a single day. This high level of fire occurrence was recorded five times in the Gila Wilderness Area as follows:

| | |
|---|---|
| May 16, 1961 | 23 fires |
| July 19, 1970 | 16 " |
| June 24, 1971 | 17 " |
| July 2, 1974 | 18 " |
| July 3, 1974 | 17 " |

Table V-8. Summary of Lightning Fires in Wilderness and Primitive Areas in Region Three National Forests (7 year period 1960 and 1961, 1970 thru 1974).

| National Forest | Area | Acres in Area | No. of Fires | Fires Per Million Acres (An Ave.) | No. Class C or Larger Fires | % Class C or Larger | Acres Burned |
|---|---|---|---|---|---|---|---|
| Apache | Blue Range P.A. | 211,710 | 320 | 216 | 18 | 5.62 | 947 |
| " | Mt. Baldy W.A. | 7,106 | 0 | 0 | 0 | 0 | 0 |
| Carson | Wheeler Peak W.A. | 6,029 | 0 | 0 | 0 | 0 | 0 |
| Carson and Santa Fe | Pecos W.A. | 167,416 | 10 | 9 | 1 | 10.00 | 42 |
| Coronado | Chiricahua W.A. | 18,000 | 79 | 627 | 2 | 11.39 | 174 |
| " | Galiro W.A. | 52,717 | 15 | 41 | 2 | 13.33 | 232 |
| Coconino, Kaibab & Prescott | Sycamore Canyon W.A. | 47,762 | 63 | 188 | 2 | 3.17 | 35 |
| Gila | Gila W.A. and P.A. | 566,704 | 1000 | 252 | 26 | 2.60 | 2,028 |
| " | Black Range P.A. | 169,984 | 316 | 266 | 2 | 0.63 | 91 |
| Lincoln | White Mtns W.A. | 31,283 | 9 | 41 | 1 | 11.11 | 76 |
| Prescott & Tonto | Pine Mtn W.A. | 20,061 | 14 | 100 | 0 | 0 | 6 |
| Santa Fee Tonto | San Pedro Parks W.A. | 41,132 | 9 | 31 | 0 | 0 | 0 |
| | Mazatzal,W.A. | 205,346 | 43 | 30 | 4 | 9.30 | 80 |
| " | Sierra Ancha W.A. | 20,850 | 34 | 233 | 5 | 5.88 | 100 |
| " | Superstition | 124,140 | 24 | 28 | 5 | 20.83 | 261 |
| TOTALS | | 1,690,240 | 1936 | 164 | 65 | 3.36 | 4,072 |

Table V-9. Summary of Wilderness and Primitive Area Lightning Fires, Apache and Gila National Forests, 1960-1961 and 1970-1974.

| Year | Apache National Forest | | Gila National Forest | | | |
|---|---|---|---|---|---|---|
| | Blue Range P.A. | | Gila W.A. and P.A. | | Black Range P.A. | |
| | No. Fires | Acres Burned | No. Fires | Acres Burned | No. Fires | Acres Burned |
| 1960 | 31 | 17 | 142 | 53 | 30 | 21 |
| 1961 | 37 | 218 | 202 | 53 | 60 | 45 |
| 1970 | 51 | 325 | 139 | 984 | 58 | 0 |
| 1971 | 65 | 121 | 162 | 117 | 43 | 0 |
| 1972 | 47 | 0 | 139 | 26 | 39 | 0 |
| 1973 | 30 | 60 | 77 | 0 | 33 | 0 |
| 1974 | 59 | 206 | 139 | 795 | 53 | 25 |
| TOTAL | 320 | 947 | 1000 | 2028 | 316 | 91 |
| Average Size Per Fire | | 2.96 | | 6.42 | | 0.29 |

More than 215 fires per million acres occur in five Wilderness and Primitive Areas. As shown in Table V-8 the Blue Range and Black Range Primitive Areas and the Chiricahua, Gila and Sierra Ancha Wilderness Areas all have average annual lightning fire occurrence densities of more than 215 fires per million acres. The peak density of 627 fires per million acres is in the Chiricahua Wilderness Area. This is the greatest lightning fire density of any wilderness area in Region Three, but as shown later is exceeded by two wilderness study areas.

## Wilderness Study Areas

The twenty wilderness study areas in Arizona recorded 256 lightning fires in seven years. Five of these areas - the Secret Mountain Red Rock (Coconino), Portal Peak and Black Rock (Coronado), Castle Creek (Prescott) and Alder Creek (Tonto) had more than 15 lightning fires during the study period. The Secret Mountain Red Rock Wilderness Study Area had 76 fires to lead all areas in Arizona (Table V-10).

The average annual lightning fire density in Arizona Wilderness Study Areas is 96 fires per million acres. This may be compared to the occurrence densities of 111 and 68 fires in the Northwest and Southwest Zones of Arizona National forests (Table II-G). Nine of the Wilderness Study Areas in Arizona recorded an annual average of more than 150 fires per million acres. The Sierra Ancha Addition, Tonto National Forest recorded the highest occurrence rate of any type of area in Region Three. The 11 lightning fires on only 1500 acres in this wilderness study area amount to an average annual occurrence of 1048 fires per million acres (Table V-10).

The area burned in Arizona Wilderness Study Areas by Lightning Fires was 7103 acres. The Portal Peak (Coronado), Castle Creek (Prescott) and Alder Creek (Tonto) Wilderness Study Areas all burned more than 500 acres. Alder Creek lead all areas with 5247 acres burned accounting for 73.87 percent of the area burned in Arizona Wilderness Study Areas. Class C or larger fires accounted for 7.49 percent of the total wilderness study area fires in the state (Table V-10).

The 24 wilderness study areas in New Mexico recorded 295 lightning fires in seven years. No lightning fires occurred in six of these areas. As shown in Table V-11 there were seven areas with more than 20 lightning fires. The Frisco Wilderness Study Area, Gila National Forest recorded 80 fires to lead all areas in New Mexico.

The average annual lightning fire density in New Mexico Wilderness Study Areas is 99 fires per million acres. Seven of the areas recorded an average annual occurrence of more than 120 fires per million acres and three more than 200. Peak occurrence density was 802 lightning fires per million acres in the Frisco Wilderness Study Area. This is the second highest lightning fire occurrence rate of any type of area in Region Three. It again illustrates the

potential magnitude of lightning fires in the various types of wilderness areas in the Gila National Forest (Tables V-9 and V-11).

A relatively small area has been burned by lightning fires in New Mexico Wilderness Study Areas. Only nine areas reported any acres burned. In these areas 843 acres were burned in the seven year study period. The Apache Kid (Cibola) and Southern Guadalupe (Lincoln) Wilderness Study Areas recorded burns of 345 and 332 acres respectively to account for 80.31 percent of the area burned in New Mexico. Only 4.07 percent of the fires in the New Mexico areas were Class C or larger in size (Table V-11).

Table V-10. Summary of Lightning Fires in New Wilderness Study Areas in Arizona National Forests (7 year period 1960 and 1961, 1970 thru 1974).

| National Forest | Wilderness Study Area | Acres in Area | No. of Fires | Fires Per Million Acres (An Ave.) | No Class C or Larger | % Class C or Larger | Acres Burned |
|---|---|---|---|---|---|---|---|
| Coconino | Secret Mtn Red Rock | 30,743 | 76 | 290 | 1 | 1.32 | 145 |
| " | Fossil Creek Headwaters | 11,720 | 13 | 158 | 0 | 0 | 0 |
| " | Wet Beaver | 8,794 | 8 | 325 | 0 | 0 | 0 |
| Coronado | Portal Peak | 16,000 | 20 | 179 | 1 | 5.00 | 530 |
| " | Jones Ridge | 3,500 | 4 | 163 | 0 | 0 | 0 |
| " | Erickson | 9,000 | 10 | 159 | 0 | 0 | 0 |
| " | Black Rock | 14,100 | 16 | 162 | 1 | 6.25 | 27 |
| " | Tumacacori | 39,600 | 10 | 36 | 3 | 30.00 | 95 |
| Kaibab | Kanab Creek | 71,000 | 8 | 16 | 0 | 0 | 0 |
| " | Saddle Mtn | 8,400 | 15 | 255 | 0 | 0 | 0 |
| Prescott | Granite Mtn | 5,500 | 2 | 52 | 0 | 0 | 0 |
| " | Castle Creek | 15,000 | 18 | 171 | 2 | 11.11 | 730 |
| Tonto | Verde | 31,840 | 3 | 13 | 2 | 66.67 | 102 |
| " | Hells Gate | 32,840 | 11 | 48 | 0 | 0 | 0 |
| " | Sierra Ancha Addition | 1,500 | 11 | 1048 | 0 | 0 | 5 |
| " | Salome | 14,900 | 5 | 48 | 1 | 20.0 | 62 |
| " | Alder Creek | 30,500 | 18 | 80 | 8 | 47.06 | 5247 |
| " | Goldfield | 11,300 | 0 | 0 | 0 | 0 | 0 |
| " | Lime Creek | 21,800 | 6 | 39 | 0 | 0 | 0 |
| " | Superstition Additions | 20,500 | 2 | 14 | 1 | 50.00 | 160 |
| TOTALS | | 398,577 | 256 | 96 | 20 | 7.49 | 7103 |

Table V-11. Summary of Lightning Fires in New Wilderness Study Areas in New Mexico National Forests (7 year period 1960 and 1961, 1970 thru 1974).

| National Forest | Wilderness Study Area | Acres in Area | No. of Fires | Fires Per Million Acres (An. Ave.) | No. Class C or Larger | % Class C or Larger | Acres Burned |
|---|---|---|---|---|---|---|---|
| Apache | Aspen Mtn | 17,600 | 15 | 122 | 0 | 0 | 0 |
| Carson | Latir Peak | 18,600 | 2 | 15 | 0 | 0 | 0 |
| " | Columbine Hondo | 34,600 | 8 | 33 | 0 | 0 | 0 |
| " | South Fork | 9,400 | 0 | 0 | 0 | 0 | 0 |
| " | Jicarita Creek | 10,440 | 0 | 0 | 0 | 0 | 0 |
| " | Cruces Basin | 17,600 | 3 | 24 | 0 | 0 | 0 |
| " | Sierra Negra | 8,300 | 0 | 0 | 0 | 0 | 0 |
| " | Canjilon Mtn | 5,000 | 0 | 0 | 0 | 0 | 0 |
| Cibola | Guadalupe | 6,320 | 0 | 0 | 0 | 0 | 0 |
| " | Apache Kid | 61,400 | 30 | 70 | 3 | 10.00 | 345 |
| " | Ryan Hill | 28,000 | 25 | 128 | 2 | 8.00 | 20 |
| " | Manzano | 27,000 | 16 | 85 | 1 | 6.25 | 88 |
| Gila | Frisco | 14,246 | 80 | 802 | 0 | 0 | 14 |
| " | Gila Additions | 16,493 | 6 | 52 | 0 | 0 | 0 |
| " | Gila Contiguous | 19,000 | 17 | 128 | 0 | 0 | 1 |
| Lincoln | Capitan Mtn | 29,600 | 44 | 212 | 1 | 2.27 | 16 |
| " | Southern Guadalupe | 19,800 | 6 | 43 | 4 | 66.67 | 332 |
| " | White Mtns | 12,880 | 22 | 244 | 1 | 4.55 | 21 |
| Santa Fe | San Pedro Park Addition | 5,500 | 4 | 104 | 0 | 0 | 0 |
| " | North Fork Lake | 1,420 | 0 | 0 | 0 | 0 | 0 |
| " | Bear Creek | 4,550 | 3 | 94 | 0 | 0 | 6 |
| " | Santa Fe River | 7,545 | 0 | 0 | 0 | 0 | 0 |
| " | Parito Basin | 33,700 | 9 | 38 | 0 | 0 | 0 |
| " | Macho Canyon | 18,000 | 5 | 40 | 0 | 0 | 0 |
| TOTALS | | 426,994 | 295 | 99 | 12 | 4.07 | 843 |

## Summary of Wilderness Fire Load

Table V-12 presents a summary of the lightning fire load in wilderness, primitive, wilderness study and non-wilderness areas in Region Three. The following are major features of the total present and possible future lightning fire load in wilderness and the relationships to the overall load in the region.

1. Lightning fire occurrence per million acres is greater in present wilderness and primitive areas than in non-wilderness areas.
2. Addition of the Wilderness Study Areas to the officially designated wilderness system will increase number of lightning fires to be managed under wilderness policies by 59 percent.
3. The average annual area burned per million acres by lightning fires in present wilderness and primitive areas is only one-fifth that burned in non-wilderness areas.
4. The average annual area burned per million acres by lightning fires in wilderness study areas is four times greater than in present wilderness and primitive areas, but slightly smaller than in non-wilderness areas.
5. A higher percentage of lightning fires reach Class C or larger size in all types of wilderness areas than in non-wilderness areas.
6. The average size per lightning fire in present wilderness and primitive areas is only one-eighth as large as fires in non-wilderness areas.
7. The average size per lightning fire is 7 times greater in wilderness and primitive areas, but slightly smaller than in non-wilderness areas.
8. The total lightning fire load in all types of wilderness areas accounts for 15 percent of the fires and 5 percent of the area burned in Region Three.

Table V-12. Summary of Lightning Fire Load in Wilderness, Primitive, Wilderness Study and Non-Wilderness Areas in Region Three, 1960-1961 and 1970-1974.

| | Wilderness and Primitive Areas | Wilderness Study Areas | Non-Wilderness Areas | Total All Areas |
|---|---|---|---|---|
| Total No. of Fires | 1936 | 551 | 13923 | 16410 |
| Annual Average No. of Fires | 277 | 79 | 1989 | 2344 |
| Acres in Area | 1,690,240 | 825,531 | 19,626,040 | 22,141,811 |
| Annual Average No. of Fires Per Million Acres | 164 | 96 | 101 | 106 |
| Total Acres Burned | 4072 | 7949 | 232,570 | 244,591 |
| Annual Average Acres Burned | 582 | 1136 | 33224 | 34,942 |
| Annual Average Area Burned Per Million Acres | 344 | 1376 | 1693 | 1578 |
| Total No. Class C or Larger Fires | 65 | 32 | 390 | 487 |
| % Class C or Larger Fires | 3.36 | 5.81 | 2.86 | 2.97 |
| Average Size Per Fire | 2.10 | 14.43 | 16.70 | 14.90 |
| % of Total Fires in R-3 | 11.80 | 3.36 | 84.84 | 100 |
| % of Total Burn in R-3 | 1.66 | 3.25 | 95.09 | 100 |

## V-3. Control of Wilderness Lightning Fires

The great majority of wilderness lightning fires are detected from lookout stations. During the seven year study period 63.41 percent of the fires were detected by Forest Service lookouts. In both wilderness and primitive areas and wilderness study areas lookouts are the dominant method of lightning fire detection (Table V-13). It was not determined how many of these lookouts were in wilderness or in adjacent non-wilderness areas. It is significant to note, however, that lookout stations including their supporting communication, transportation and supply systems have played a major role in providing detection and continuing information on wilderness fires.

Aircraft provide the second leading method for detection of wilderness lightning fires. Forest Service aircraft detected 20.31 percent of the fires. Other aircraft detected 1.97 percent. In all types of wilderness only 14.11 percent of the fires were detected by ground based personnel other than lookouts (Table V-13).

Wilderness lightning fires are detected relatively fast. As shown in Table V-15 more than 50 percent of them are detected within three hours. However, it should be noted that 34 percent of the fires had elapsed detection times of more than 12 hours.

Airborne control forces provide the primary method of initial attack for wilderness lightning fires. Air tankers, smokejumpers and helitack crews were used in initial attack on 60.32 percent of the fires. Helitack crews lead all other methods of initial attack accounting for 39.88 percent of the fires (Table V-14). In the wilderness and primitive areas smokejumpers made initial attack on 18.41 percent of the fires.

Plow-trenchers and ground tankers have been used in initial attack of wilderness fires. In established wilderness and primitive areas plow-trenchers were used on 7 fires and ground-tankers on 17 fires. In wilderness study areas ground tankers were used on 19 fires (Table V-14).

Table V-13. Distribution of Wilderness Lightning Fires By Detection Method, 1960-1961 and 1970-1974.

| Detection Method | Wilderness and Primitive Areas No. Fires | Wilderness Study Areas No Fires | Total No. | Total % |
|---|---|---|---|---|
| F.S. Lookout | 1307 | 270 | 1577 | 63.41 |
| Other Lookout | 3 | 2 | 5 | 0.21 |
| Patrolman | 16 | 36 | 52 | 2.09 |
| Other F.S. | 121 | 45 | 166 | 6.67 |
| Cooperator | 8 | 6 | 14 | 0.56 |
| F.S. Permittee | 20 | 20 | 40 | 1.61 |
| F.S. Aircraft | 399 | 106 | 505 | 20.31 |
| Other Aircraft | 35 | 14 | 49 | 1.97 |
| Others | 27 | 52 | 79 | 3.18 |
| TOTAL | 1936 | 551 | 2487 | |

Table V-14. Distribution of Wilderness Lightning Fires By Initial Attack Method, 1960-1961 and 1970-1974.

| Initial Attack Method | Wilderness and Primitive Areas | Wilderness Study Areas | Total | |
|---|---|---|---|---|
| | No. Fires | No Fires | No. | % |
| Plow-Trenches | 7 | 0 | 7 | 0.28 |
| Ground-Tanker | 17 | 19 | 36 | 1.45 |
| Ground-Hand | 607 | 335 | 942 | 37.91 |
| Heli-Tanker | 1 | 0 | 1 | 0.04 |
| Air-Tanker | 78 | 49 | 127 | 5.11 |
| Smoke-Jumper | 356 | 25 | 381 | 15.33 |
| Helitack | 868 | 123 | 991 | 39.88 |
| TOTAL | 1934 | 551 | 2485 | |

Table V-15. Summary of Wilderness Lightning Fire Detection, Initial Attack and Control, 1960-1961 and 1970-1974.

| | Wilderness and Primitive Areas No. Fires | Wilderness Study Areas No. Fires | Total No. | Total % |
|---|---|---|---|---|
| Elapsed Detection Time | | | | |
| Within 3 Hours | 975 | 284 | 1259 | 50.62 |
| 3 - 12 Hours | 299 | 82 | 381 | 15.32 |
| Over 12 Hours | 662 | 185 | 847 | 34.06 |
| Total | 1936 | 551 | 2487 | |
| Elapsed Initial Attack Time | | | | |
| Within 3 Hours | 1616 | 428 | 2044 | 82.19 |
| 3 - 12 Hours | 197 | 86 | 283 | 11.38 |
| Over 13 Hours | 123 | 37 | 160 | 6.43 |
| Total | 1936 | 551 | 2487 | |
| Elapsed Fire Control Time | | | | |
| Within 3 Hours | 385 | 131 | 516 | 20.75 |
| 3 - 12 Hours | 474 | 140 | 614 | 24.69 |
| Over 12 Hours | 1077 | 280 | 1357 | 54.56 |
| Total | 1936 | 551 | 2487 | |

Fast initial attack is common on wilderness lightning fires. The studies of fire control show that 82.19 percent of all wilderness fires were attacked within three hours following discovery. Only 6.43 percent of the fires had elapsed initial attack times of more than 12 hours. These records for initial attack are generally similar in both wilderness and primitive areas and wilderness study areas (Table V-15).

Most wilderness lightning fires have control times of more than 12 hours. The individual fire reports show that 54.56 percent of the fires had control times of more than 12 hours following arrival of attack forces. Only 20.75 percent were controlled within 3 hours (Table V-15).

# VI. CRITICAL LIGHTNING FIRE SITUATIONS

Occasional great peaks in fire occurrence, area burned and control requirements are an exceedingly important characteristic of lightning fires. Natural resource and fire managers have long recognized these features of the lightning fire problem. The word "critical" has often been used to describe the periods, years or locations of great outbreaks of lightning fires. In this study we have focused efforts on a definition of critical lightning fire situations and on analysis of their significant features.

The study of critical lightning fire situations in Region Three is patterned after a similar study made in Region One (Barrows, Sandberg and Hart, 1976). The definition of critical situations presented in Chapter VI-1 correspond to those developed for the earlier studies in Region One. However, it is recognized that major differences in lightning fire situations exist between the two regions. These differences include:

> Region Three has a much longer lightning fire season (actually two seasons, one dry and one wet), records more total fires but has fewer fires in short time periods. Region Three has a greater average annual area burned. Region One has a shorter lightning fire season, records fewer total fires but experiences greater peak loads in short time periods.

## VI-1. Definition of Critical Lightning Fire Situations.

It has often been said that "beauty is in the eyes of the beholder." The same may be said for critical lightning fire situations. What is critical to one person or group of persons may not be judged in the same way by others. We recognize the complexity of precisely defining a critical lightning fire situation. However, the wealth of data now available on lightning fires does permit identification of those specific situations placing a critical load on fire management organizations or producing severe impacts on natural resources and society.

Critical lightning fire situations involve many factors and dimensions. These include:

(1) Time span -- single day, series of days, month, year.

(2) Location -- individual national forests, groups of forests, zones, total region.

(3) Values at stake -- timber, forage, wildlife, watersheds, recreation areas, scenic beauty, developed facilities, industries, communities, air and water pollution control, public safety.

(4) Fire occurrence -- numbers of fires by size class, time and location.

(5) Fire weather and fire danger rating -- at time of occurrence and following occurrence.

(6) Acres on fire -- by time and location.

(7) Fire control requirements -- personnel, equipment, supplies, transportation.

(8) Costs -- fire control, damage.

Complex interrelationships exist between each of these factors and their dimensions. Because of this complexity and the lack of appropriate data on many items no attempt is made to use all of the factors in developing definitions for critical situations. The available data on specific outbreaks of fires when examined in specific time periods and locations can provide a useful basis for critical definitions. In the future when additional data is available these definitions can be further examined and refined.

Fire management experience indicates that strictly from a fire viewpoint (exclusive of resource values and social concerns) the following are ingredients in a critical situation:

(1) Buildup. A period of dry weather makes fuels become highly flammable.
(2) Fire Occurrence. Combinations of large numbers of fires in a short time period (1 to 10 days) or continued new ignitions over longer periods requiring full deployment of the available initial attack forces.
(3) Fire Weather. The weather conditions during and immediately following fire ignitions provide a high potential for fire spread.
(4) Large Fires. The existence of Class D or larger fires requires a massive deployment of fire suppression forces recruited primarily from external sources.

Our analysis of lightning fires in Region Three indicates that all four of these ingredients must be present to generate a critical situation. For example:

(1) Buildup (highly flammable fuels) is a dangerous situation, but is only a threat until fires occur.
(2) Large numbers of fires even in the absence of buildup and severe fire weather can result in large scale deployment of fire attack forces. However, the experience in Region Three shows that fire management organizations have been able to effectively handle situations where the only critical ingredient is large numbers of fires.
(3) Large numbers of lightning fires may not create a critical situation if precipitation during and following the storm lowers fuel flammability. On the other hand severely dry and windy weather following ignitions can cause a high potential for a critical situation.
(4) Large uncontrolled fires impact the overall fire management organization including commitment of fire suppression resources and the continuing availability of forces to attack new fires that may occur during the periods when existing fires are being fought.

In defining critical lightning fire situations consideration also is given to the size of the area that may be impacted. The great mobility of modern fire fighting organizations strongly influences this factor. An individual national forest at some period of time may have each of the four ingredients of a critical lightning fire situation (buildup, fire occurrence, severe fire weather and large fires) and yet the result may be less than a critical situation. Other fire fighting forces within the region or available from outside the region can most often prevent full development of a critical situation. Our studies indicate that virtually every truly critical situation was of a multi-forest, regional or interregional dimension.

## VI-2. Analysis of Critical Lightning Fire Situations

As explained in the previous chapter the peak load factors of total fire occurrence, numbers of large fires and area burned are ingredients in a critical lightning fire situation. In this study we present data for each of these factors to permit judgements in identification of critical situations. Analyses of the specific weather factors related to critical situations are beyond the scope of this study. However, we have identified specific time periods and locations of peak loads which can be related to future studies of both lightning and weather factors.

### Peak Single Day Fire Loads

Peak single day lightning fire occurrence in the region exceeds 100 fires. During the 1960-1974 period there were 12 days when more than 100 lightning fires occurred. The peak occurrence of any day in the 15 years studied was June 28, 1960 when 143 lightning fires started. In 1970 there were three days with more than 100 fires including successive days on July 18 and 19. Days with more than 100 fires were recorded twice in May, four times in June, five times in July and once in August (Table VI-1).

Peak single day fire occurrence does not always signify large areas burned. Fires starting on the 12 peak occurrence days burned a total of 76,607 acres. However 98.83 percent of this area burned on a single day. The area burned exceeded 100 acres on only three other days. The average size for the 1347 fires starting on peak occurrence days was 56.87 acres (Table VI-1).

Twenty or more lightning fires occur on a single day in individual national forests. On two occasions more than 50 fires have occurred on a single day in individual forests. These peak outbreaks of lightning fires were recorded on June 28, 1960 when 57 fires started on the Coconino and July 2, 1974 when 55 started on the Gila. The six national forests recording 20 or more fires were as follows:

| | 20 + fires | 40 + fires |
|---|---|---|
| Apache-Sitgreaves | 26 days | 1 day |
| Coconino | 28 " | 2 days |
| Coronado | 4 " | |
| Kaibab | 7 " | |
| Gila | 33 " | 2 " |
| Tonto | 5 " | |

Three or more large lightning fires start in the Region on a single day. During the 1960-1974 period 3 or more Class D or larger fires started on 15 days as follows:

| | |
|---|---|
| May 2, 1960 | 4 fires |
| May 20, 1960 | 3 " |
| May 12, 1961 | 3 " |
| June 26, 1962 | 4 " |
| June 25, 1964 | 3 " |
| July 5, 1965 | 5 " |
| June 14, 1966 | 3 " |
| June 19, 1968 | 4 " |
| May 23, 1969 | 3 " |
| Aug. 4, 1969 | 3 " |
| July 3, 1970 | 3 " |
| June 24, 1971 | 6 " |
| June 25, 1974 | 3 " |
| June 29, 1974 | 6 " |
| July 1, 1974 | 3 " |

Five National Forests have had three or more large fires start in a single day. This level of single day occurrence of Class D or larger fires was recorded on individual national forests as follows:

| | | |
|---|---|---|
| Apache-Sitgreaves | June 24, 1971 | 5 fires |
| Coronado | May 2, 1960 | 4 " |
| " | May 12, 1961 | 3 " |
| " | June 26, 1962 | 4 " |
| " | July 5, 1965 | 5 " |
| " | June 19, 1968 | 4 " |
| Cibola | June 29, 1974 | 3 " |
| Gila | May 23, 1969 | 3 " |
| Tonto | July 3, 1970 | 3 " |

Lightning fires ignited on a single day may cause more than 5000 acres to be burned in the region. During the 1960-1974 period there were 17 days when

lightning fire ignitions resulted in burns of more than 5000 acres (Table VI-2). These "5000 plus" days accounted for burning 258,286 acres or 70.88 percent of the area burned in Region Three during the 15 year period. These days exhibit many of the characteristics of critical lightning fire situations including multiple ignitions, many Class D or larger fires and requirements for large numbers of fire fighters. More than 25 lightning fires started on 15 of the 17 "5000 plus" days. There were 41 Class D or larger fires. The average size per fire was 315.37 acres. June 24, 1971 was the most critical lightning fire day in the 15 year period with 103 fires and 75,713 acres burned.

Table VI-1. Number of Fires by Size Class and Area Burned on Days When More Than 100 Lightning Fires Occurred in Region Three, 1960-1974.

| Date | A | B | C | D | E | F | G | Total | Acres Burned |
|---|---|---|---|---|---|---|---|---|---|
| 6-28-60 | 119 | 23 | 1 | | | | | 143 | 41 |
| 5-16-61 | 90 | 11 | 1 | 1 | | | | 103 | 319 |
| 5-24-61 | 93 | 18 | 4 | 1 | | | | 116 | 246 |
| 6-29-62 | 110 | 2 | | | | | | 112 | 12 |
| 8-16-62 | 105 | 20 | | | | | | 125 | 27 |
| 7-7-70 | 91 | 11 | 2 | | | | | 104 | 59 |
| 7-18-70 | 87 | 16 | | | | | | 103 | 0 |
| 7-19-70 | 97 | 20 | 2 | | | | | 119 | 105 |
| 6-24-71 | 53 | 38 | 6 | | | 3 | 3 | 103 | 75,713 |
| 7-16-71 | 90 | 20 | 2 | | | | | 112 | 40 |
| 6-3-72 | 95 | 11 | | | | | | 106 | 30 |
| 7-8-73 | 88 | 12 | 1 | | | | | 101 | 15 |
| Total | 1118 | 202 | 19 | 2 | | 3 | 3 | 1347 | 76,607 |
| | | | | | | | Average Size Per Fire | | 56.87 |

Table VI-2. Summary of Fire Load on Days When Lightning Fire Ignitions Resulted in Burning More Than 5000 Acres in Region Three, 1960-1974.

| Year | Date | Regional Totals | | National Forests With Class D or Larger Fires | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. of Fires | Acres Burned | No. of Fires | Acres Burned | | | | |
| | | | | Coronado | | | | | |
| 1960 | 5-2 | 34 | 7212 | 4 | 6187 | | | | |
| | | | | Kaibab | | | | | |
| | 5-21 | 4 | 8703 | 1 | 8673 | | | | |
| | | | | Gila | | | | | |
| | 7-9 | 63 | 5013 | 1 | 5000 | | | | |
| | | | | Coronado | | | | | |
| 1961 | 5-12 | 32 | 8166 | 3 | 8134 | | | | |
| | | | | Kaibab | | | | | |
| 1962 | 7-23 | 77 | 8702 | 1 | 8660 | | | | |
| | | | | Tonto | | | | | |
| 1964 | 6-27 | 54 | 5142 | 1 | 5000 | | | | |
| | | | | Coronado | | Tonto | | | |
| 1965 | 7-13 | 54 | 6805 | 1 | 6664 | 1 | 132 | | |
| | | | | Tonto | | Coronado | | | |
| 1966 | 5-14 | 2 | 12,720 | 1 | 12,720 | | | | |
| | 6-14 | 53 | 8817 | 2 | 8125 | 1 | 450 | | |
| | | | | Coronado | | | | | |
| 1968 | 6-19 | 60 | 23,335 | 4 | 23,277 | | | | |
| | | | | Tonto | | | | | |
| 1970 | 7-3 | 48 | 13,412 | 3 | 13,400 | | | | |
| | | | | Apache-Sitgreaves | | Coronado | | Santa Fe | |
| 1971 | 6-24 | 103 | 75,713 | 5 | 74,340 | 1 | 1210 | | |
| | 6-26 | 27 | 13,110 | | | | | 1 | 12,920 |
| | | | | Tonto | | Coronado | | | |
| 1974 | 6-23 | 28 | 8320 | 1 | 8320 | | | | |
| | 6-26 | 45 | 5150 | | | 1 | 5087 | | |
| | 6-28 | 59 | 27,846 | | | | | Gila 2 | 27,662 |
| | | | | Cibola | | Coronado | | Lincoln | |
| | 6-29 | 76 | 20,120 | 3 | 940 | 1 | 2400 | 2 | 16,437 |
| Total | | 819 | 258,286 | | | | | | |
| Average Size Per Fire | | | 315.37 | | | | | | |

## Peak Multiple Day Fire Loads

Peak lightning fire loads during four to ten day periods have occurred in Region Three. During the 1960-1974 period there were 14 periods when combinations of multiple lightning fire ignitions and large fires generated major fire loads for four or more successive days (Table IV-3). The 86 days included in these 14 periods accounted for 3707 lightning fires and 291,741 acres burned. There were 220 Class C or larger fires or 5.93 percent. All of the Class G fires during the 15 years studied occurred during the 14 peak load periods. The average size per fire during these periods was 78.70 acres. The area burned amounted to 80.06 percent of the 15 year regional total.

Peak lightning fire loads may last for nearly three weeks. During the 18 day period June 16 through July 3, 1971 a total of 617 lightning fires burned 92,218 acres (Figure VI-1.). New fires occurred on every day of the period and 30 or more occurred on 9 days. In one three day period 223 lightning fires occurred. These were 14 Class D or larger fires. On all but one day of the period large fires were out of control. Another long period of intensive fire activity occurred June 23 through July 5, 1974 (Figure VI-2.). During this period 781 lightning fires burned 62,245 acres. There were 28 or more new fires every day of the period. In one four day period 301 fires started. There were 21 Class D or larger fires. Large fires were out of control for 12 straight days.

Man-caused fires may compound critical lightning fire situations. It was not the purpose of this study to evaluate man-caused fires. However, it is recognized that the critical lightning fire situations may have been further amplified by requirements for control of man-caused fires. A total evaluation of both lightning and man-caused fires is needed.

Table VI-3. Summary of Lightning Fire Load During Critical Periods of Days in Region Three, 1960-1974.

| Year | Dates | A | B | C | D | E | F | G | Total | Acres Burned |
|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 5,1-5 | 178 | 53 | 11 | 1 | 2 | 3 | 0 | 248 | 10,761 |
| | 5,19-23 | 30 | 11 | 3 | 0 | 3 | 2 | 1 | 50 | 13,269 |
| | 7,5-9 | 223 | 20 | 5 | 0 | 1 | 0 | 1 | 250 | 5,851 |
| 1961 | 5,11-17 | 277 | 47 | 4 | 1 | 1 | 2 | 1 | 333 | 11,284 |
| 1962 | 7,21-24 | 191 | 8 | 1 | 0 | 0 | 0 | 1 | 201 | 8,822 |
| 1964 | 6,24-29 | 228 | 30 | 5 | 4 | 1 | 1 | 0 | 269 | 6,419 |
| 1965 | 7,3-8 | 163 | 32 | 17 | 1 | 3 | 2 | 0 | 218 | 7,147 |
| | 7,10-14 | 269 | 24 | 2 | 2 | 0 | 0 | 1 | 298 | 7,207 |
| 1966 | 5,14-20 | 26 | 9 | 0 | 0 | 0 | 0 | 1 | 36 | 12,732 |
| | 6,14-20 | 219 | 61 | 13 | 2 | 3 | 1 | 1 | 300 | 12,036 |
| 1968 | 6,17-22 | 99 | 55 | 7 | 1 | 3 | 2 | 1 | 168 | 26,344 |
| 1970 | 7,2-9 | 371 | 56 | 9 | 0 | 3 | 2 | 1 | 442 | 15,522 |
| 1971 | 6,22-26 | 148 | 103 | 11 | 2 | 0 | 3 | 4 | 271 | 89,229 |
| 1974 | 6,23-7,2 | 390 | 166 | 46 | 11 | 5 | 1 | 4 | 623 | 65,118 |
| Total | | 2812 | 675 | 134 | 25 | 25 | 19 | 17 | 3707 | 291,741 |

**Summary of Critical Lightning Fire Period, June 16 - July 3, 1971,**

**617 Fires. 92,218 Acres Burned**

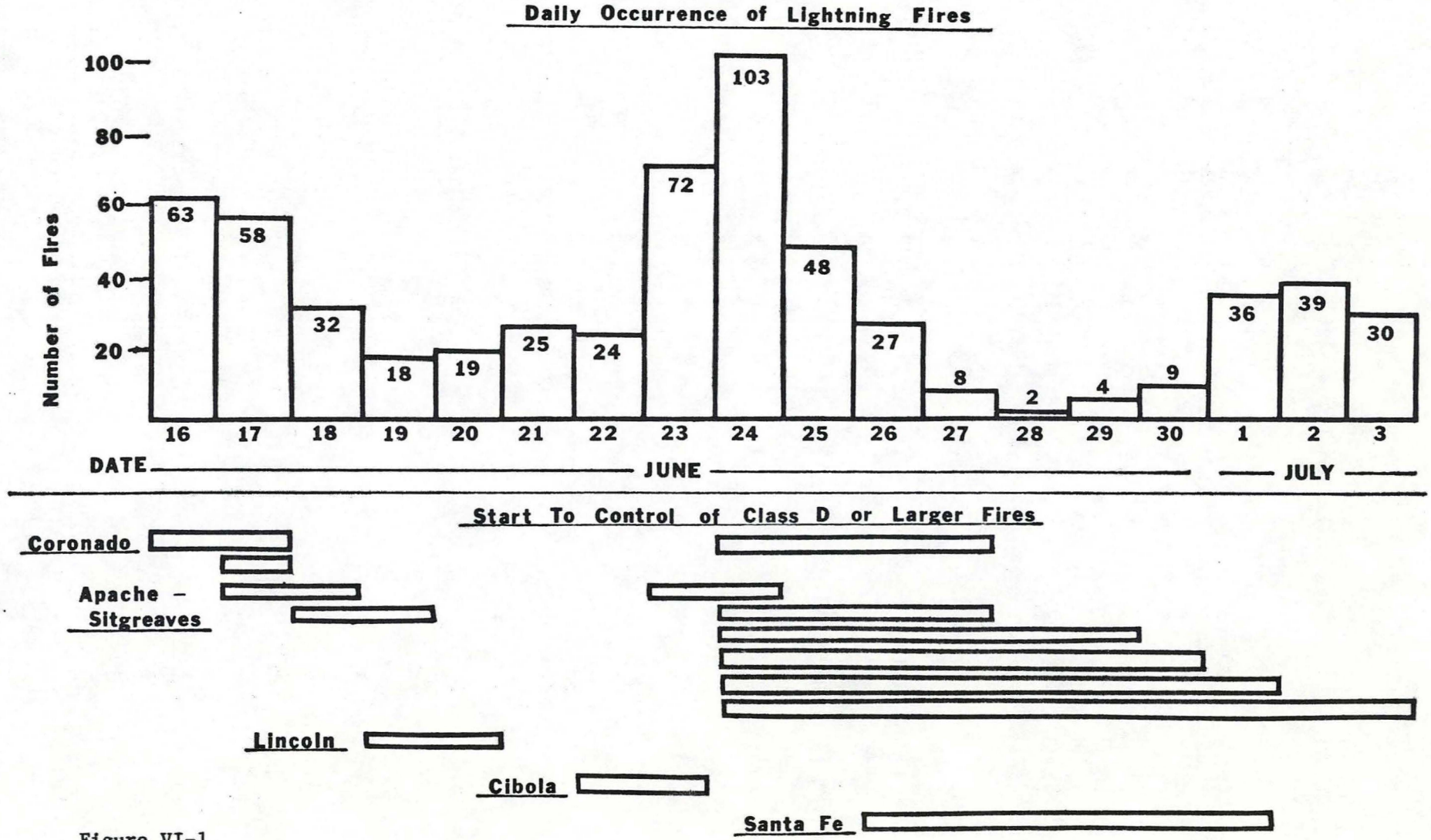
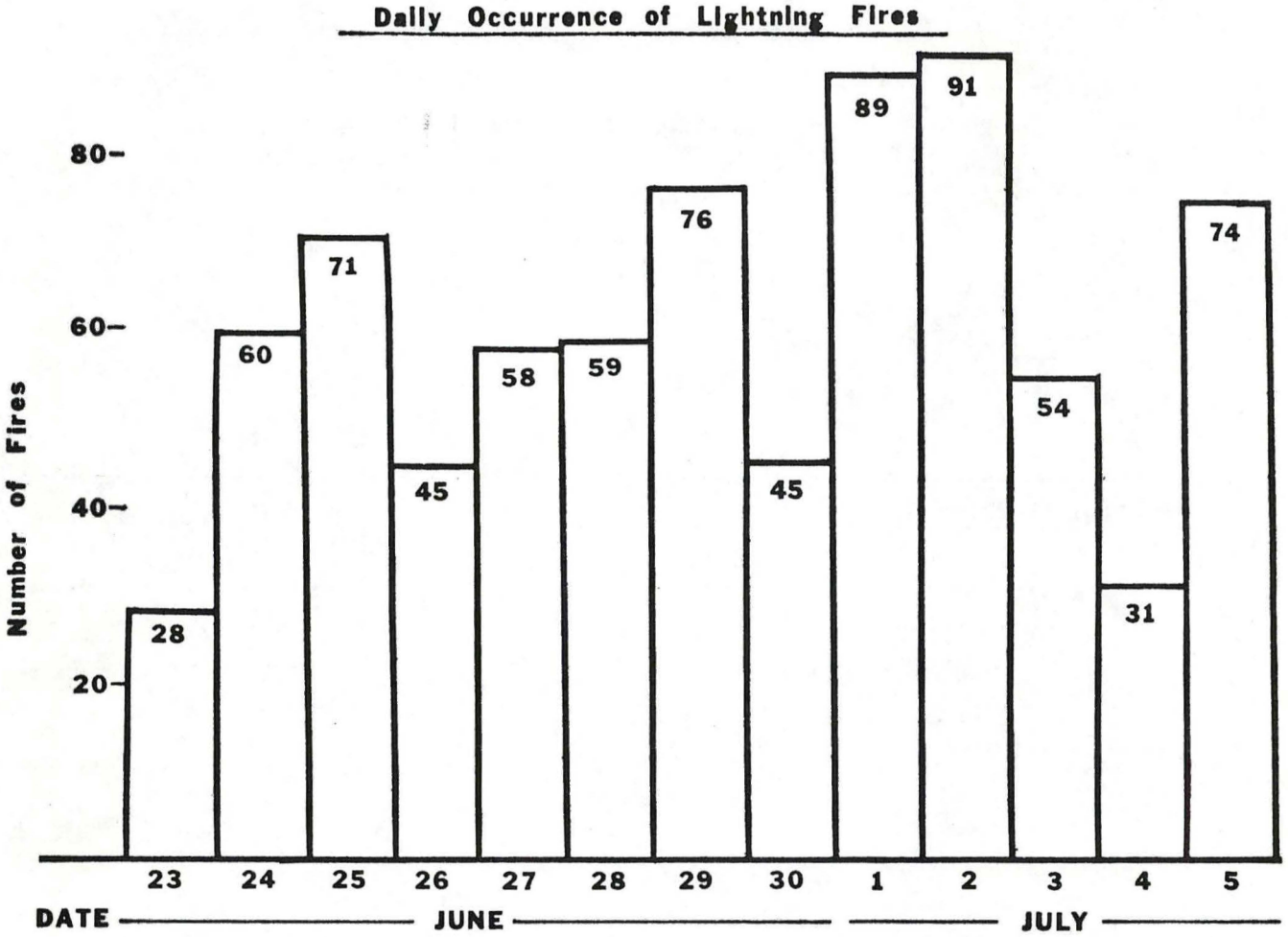



Figure VI-1.

June 23 - July 5, 1974, 781 Fires. 62,245 Acres Burned



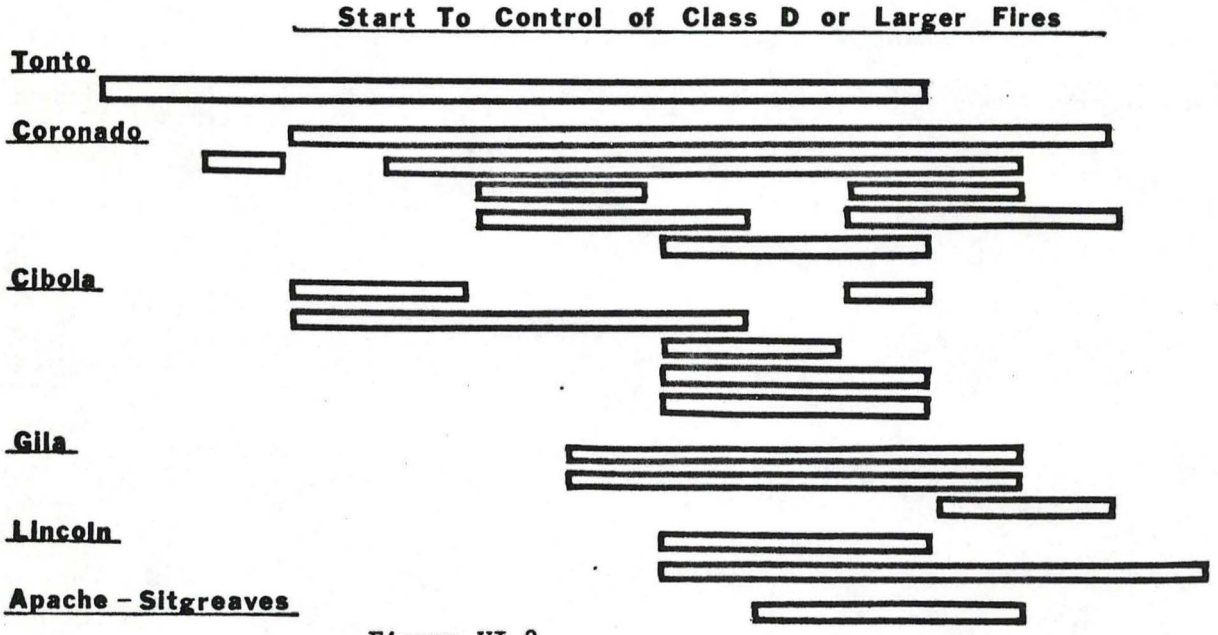




Figure VI-2.

## Summary of Critical Situations

The analyses of lightning fires shows that critical situations may occur in all zones in Region Three. The following periods appear to be major candidates for designation as critical situations:

| Date | Total Fires | Class D or Larger Fires | Acres Burned | |
|---|---|---|---|---|
| Single Day | | | | |
| June 24, 1971 | 103 | 6 | 75,713 | Central and SW Zones |
| Multiple Days | | | | |
| June 17-22, 1968 | 168 | 7 | 26,344 | Central and SW Zones |
| July 2-9, 1970 | 442 | 6 | 15,222 | SW Zone |
| June 16-July 3, 1971 | 617 | 14 | 92,218 | Central and Eastern Zones |
| June 23-July 5, 1974 | 781 | 20 | 62,245 | SW, Central and Eastern Zones |

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# APPENDIX

## Appendix

To supplement the data tables contained in the report a voluminous amount of data from computer runs of 28377 individual fire reports are available. The magnitude of the total data is too great for inclusion in the appendix. Computer tapes and hard copy printouts are available as follows:

1. Complete listing of all coded data for all fires.
2. Regional analysis of fire load by individual days, ten day periods, months and years.
3. Fire load analysis for each national forest by individual days, ten day periods, months and years.
4. Abnormal fire load analysis by days for each national forest.
5. Fire environment analysis for each zone and national forest.
6. Fire control analysis for each zone and national forest.
7. Analysis of fire load by dates and fire environment and fire control for each wilderness, primitive and wilderness study area.

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